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A TREATISE

ON THE

EXTERNAL CHARACTERS

OF

MINERALS.

BY

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AN IMPROVED TRANSLATION FROM THE GERMAN, WITH EXPLANATORY NOTES.

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PREFACE.

WE have availed ourselves in this work of the labours of Mr. Weaver,[1] who published a translation in 1805, which possesses the merit of embodying manuscript corrections by the author himself, additions which he had circulated amongst his pupils, notes taken during his lectures in 1791-92, and hints from the mineralogies of his disciples, Wiedenmann and Emmerling. The synonymes of Kirwan, agreeing as they do in all material points with those of Jamieson, Phillips, Chapman, and those of the Editor, have been retained.

There is, however, one point in which we have departed both from the original of 1774 and Weaver's translation of 1805, viz. that we have reduced the additions made from the sources above-named to the same text, as near as might be, as the original work—embodying the improvements without adding much that is immaterial to the study of the subject, which is, however, to be found in the previous translation.

[1] A Treatise on the External Characters of Fossils, by A. G. Werner, translated by Thomas Weaver. 8vo. Dublin, 1805.

Reference has been made in many instances to a kindred work by Mr. Chapman (entitled "A Brief Description of the Characters of Minerals"[1]), a gentleman well acquainted with this work of our author, who has adopted a course similar to the one of which we have spoken, but who was not confined to any prescribed text. Possessing peculiar requisites for the task, in having studied the subject in German mining schools, the Committee trust that the labours of the Editors of this translation will have produced a work reflecting credit on the Club and honour on the illustrious man from whom the one has emanated, and after whom the other has been named.

The Wernerian Club.

[1] Baillière, London, 1844.

Preface of the Author.

"In verbis non simus faciles ut conveniamus in re."

UNDER the title of this small work the reader is promised a "Treatise on the External Characters of Minerals;" I have, however, taken the liberty of exceeding the exact limits of the subject to express, at the same time, my ideas on the deficiencies of the science of Mineralogy in general, and to point out the means of removing them.

Among these I consider the neglect in describing minerals according to External Characters one of the most prominent; and as I am of opinion that such descriptions are most needful in Mineralogy, my attention has been chiefly directed to the consideration of the External Characters, and, for that reason, these form the principal subject of the present work.

Accordingly, I have shewn that these characters are not to be applied as hitherto to the systematic classification of minerals; but merely to fix the conception of their external form, &c., and to fix the method of describing them: that the External Characters hitherto in use are very indeterminate, and that the perfection and utility of external description depends on the complete definition and arrangement of the External Characters.

To remove these defects, to some extent at least, I have not only endeavoured to determine and to convey a proper idea

of their External Characters, and to define each in particular as accurately as may be, but I have also pointed out the method of drawing up complete and systematised descriptions founded on the characters. And, for the sake of greater clearness and precision, I have illustrated the whole by examples.

I have also added a concise history of the External Characters, noticing those Mineralogists alone whose works are in any way remarkable.

It will be found that I have treated the subject in a way of my own; whether justly or not, I leave to the decision of Mineralogists, having sufficiently detailed my reasons for so doing.

I shall rejoice and feel rewarded for my labour if my small work is honoured with a full inquiry; nay, even should I be refuted on good grounds, in points wherein I have erred in departing from opinions generally received, or where I have proved correct, if I receive assistance to its further improvement for the advancement of Mineralogy.

But should Mineralogy be hereafter cultivated on the principles I propose, some might spare us the perusal of their writings; for to execute a work on Mineralogy would no longer be an easy task, and would require much labour and acuteness in observation. A work conducted on this plan would prove more useful and beneficial than all those which have hitherto appeared, particularly if executed by an able, experienced, and attentive Mineralogist.[1] In this case, should we meet with a mineral of which we have had no knowledge, nothing more would be requisite, in order to ascertain its name and to know to what species it belonged, than to study the External Characters and to refer the idea thus conveyed to the description in the system: or should

[1] This was accomplished in part by Mr. Werner himself, in his edition of Cronstedt, in 1780; and the same principles have been since followed in the Mineralogies of Lenz, Wiedenmann, Emmerling, Estner, and Brochant; but for a complete exposition of the Wernerian doctrines we may look to the systematic work of Mr. Jamieson, of which the first volume has recently appeared.—*Trans.*

we find minerals mentioned in the system which we had never yet seen, complete external conceptions might be immediately derived from the descriptions of them, by which they might be recognised whenever they occur, without troubling ourselves with uncertain or groundless conjectures.

With this apology, I commit my small work to the judgment of the mineralogical public. It has at least the merit of good intention. Should it receive approbation, I shall in future hold myself bound to communicate the results of my mineralogical labours.

Lastly, I trust that the liberty which I have taken of expressing my sentiments on the writings and opinions of others, will be thought justified by the good object which I had in view, which was no other than the advancement of Mineralogy.

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INTRODUCTION.

Of Mineralogy in General.

SECT. 1.—VALUE is attached to all sciences; the degree, however, varies, some being more extensively useful than others, and having more immediate relation to the wants of life.

SECT. 2.—Mineralogy, or the natural history of minerals,[1] is one of the most generally useful, and is nearly indispensable to society. To the miner, smelter, physician, chemist, natural philosopher, &c. its utility is too well known to need particular notice here; and it would be foreign to my present design to dwell on the advantages of this science.

SECT. 3.—There are several branches of mineralogy. *Oryctognosy* is, without doubt, the most important, especially as it is the foundation of *Geognosy* and *Mineralogical Geography*.

German mineralogists divide the science as follows:—

Oryctognosy—or the recognition of minerals by affinities, *i.e.* characters.

Chemical Mineralogy—or the science of analysis.

Geognosy—or Geological Mineralogy.

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[1] We have adopted the term "minerals" in preference to the more literal rendering of the German, in consequence of the term "fossils" being now generally applied to organic remains, &c. imbedded in strata. —*Wern. Club.*

Mineralogical Geography—or the geographic distribution of minerals.

Economical Mineralogy—or the knowledge of the economic purposes to which minerals may be applied.

See Leonhard's "Handbuch der Mineralogie."—*Wern. Club.*

Sect. 4.—Since the study of this science became more general (a period of near forty years[1]), it has been cultivated by many learned, able, and patriotic men, with considerable ardour, and by several with considerable success; among the latter, I will only mention *Henkel*, *Linnæus*, *Wallerius*, *Bomare*, and *Cronstedt*. The multiplicity of systems which have been published are evidence of the general labours in this department of science, their number being annually increased by one, at least, without mentioning small tracts on particular subjects.

A list of the mineralogical works of these authors—with the exception of those of Linnæus, whose writings are too well known to need particularising—may not be unacceptable to the reader, especially if he take an interest in the early history of the science. Henkel's works consist principally of: "Pyritologia," 8vo., Lipsiæ, 1725; "Idea generalis de Lapidum origine," 8vo., Dresdæ et Lipsiæ, 1734; and "In Mineralogia redivivus," 8vo., Dresdæ, 1747. Wallerius, a native of Sweden, held the Chair of Chemistry in the University of Upsala, previous to the accession of Bergman in 1767, and was the author of: "Mineralogia eller Mineral-Ricket indelt och beskrifvet," 8vo., Stockholm, 1747; "Lucubrationum Academicarum specimen primum de Systematibus Mineralogicis et Systemate Mineralogico rite condendo," 8vo., Holmiæ, 1768; and "Systema Mineralogicum, quo Corpora Mineralia in classes, ordines, genera, et species, suis cum var. divisa describuntur atque observationibus, experimentis et figuris illustrantur," 2 vols. 8vo., Vindobonæ, 1778. The writings of Valmont de Bomare, a celebrated French mineralogist, comprise: "Prospectus d'un Cours sur l'Histoire Naturelle des Minéraux," 12mo., Paris, 1759; and "Minéralogie, ou novelle Exposition du Règne Minéral," 8vo., Paris, 1762—a work which went through four editions, the last of which was published in 1780. The great work of Alex. von Cronstedt, "Försök till Mineralogia eller Mineral-Rickets Upställning," 8vo., Stockholm, 1758,

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[1] The date of this treatise was A.D. 1777; so that a period of more than one hundred years has *now* elapsed.—*Wern. Club.*

was translated into English in 1765, by Von Engestrom. A second, and better edition, revised by Mendes da Costa, was also published in London in 1770.—*Wern. Club.*

Sect. 5.—This multiplicity of systems of Mineralogy, or rather of Oryctognosy, is a convincing proof that the science has not yet made the much-desired progress, since several of them contain only the names, and are only incomplete and incorrect catalogues of minerals.

Sect. 6.—When I open a work on Oryctognosy, it is with the intention, either of obtaining a general knowledge of this science, or of acquiring in particular the complete knowledge of a mineral of which I know only the name, or of learning, in respect of one which I have found, and whose external characters I have observed, its name, and what place it occupies in the system. If a work answers these purposes generally, it may be termed good, and if entirely, perfect. Now, how far our Oryctognostical works have hitherto approached this desideratum, and hence what progress the science has made toward perfection, I leave to the decision of any impartial person to determine.

Sect. 7.—Two disputed subjects obstruct the progress of Oryctognosy: the first is, that many confound it with other sciences, neglecting the essential part by dwelling upon that which does not properly belong to it, or which at most should only be added in a note. The second and most important is, the division among mineralogists, some endeavouring to found the whole science on the external characters, others, on the contrary, attempting to accomplish everything by means of chemistry, and by discovering the constituent principles of minerals.

Sect. 8.—I shall not at present enter so far into the subject as to bring forward arguments in opposition to one or other of these opinions. I will only remark, that neither party considers that, to class minerals in a system, and to identify them from a consideration of their exterior, are two distinct things; and that to attain either end, very different means must be employed. In fact, the impracticability of

either plan alone is evident, since every member of the former party has felt the necessity of applying the chemical constitution of minerals to his system. The latter have referred, in some degree, to the external characters to describe species, and to distinguish varieties.

Since Werner's time, the attention of all naturalists has been gradually directed to the foundation of systems based upon *natural distinctions*. Zoology and botany have long had their advocates in this respect, and at length a similar feeling has set in with reference to mineralogy. The inadequacy of external characters as the nucleus of arrangement, even so far as crystallography itself is concerned, has led to chemical affinities being almost universally adopted, to the exclusion of every other plan. The value of external characters is not, however, lessened by this change. What the Linnæan system of plants is to botany, external characters are to mineralogy—without them identification would be extremely difficult, and the more perfect system rendered practically useless.—*Wern. Club.*

SECT. 9.—*Wallerius*[1] was the first who thought of uniting these two parties; and for this purpose proposed (thinking thereby to approach nearer to the true nature of the subject) that the external characters should be considered as subsidiary, although, in the distribution of minerals, the chief regard should be had to their constituent principles, in such a manner that the orders and genera should be principally determined by the constitution, but the species by the external characters, in preference to any others.

Gerhard[2] has lately published a plan for a correct arrangement of minerals on the natural system, in which he also endeavours, in some measure, to unite the two opinions. He proposes to determine the classes, orders, and sections of minerals by their constitution and chemical relations, and, if possible, the genera and species also; but if this mode of identification should be found insufficient for the two latter,

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[1] De Systematibus Mineralogicis et systemate Mineralogico rite condendo. Holmiæ, 8, 1768. § 102 and 103.

[2] Beyträge zur Chemie und Geschichte des Mineral-Reichs, 1 Theil. Berlin, 8, 1773. S. 13.

then to employ the external characters likewise, and especially the structure and the cohesion of the particles.

SECT. 10.—I must admit, these two authors, particularly the latter, approach very near to the nature of the subject; yet their opinions appear to me rather indeterminate. My opinion is, that the classification of minerals should be founded on their constitution, extending to their species. For a system has no other object than to determine the natural order or succession of the different minerals; and the more accurately this is accomplished, the more perfect will the system be. Now, the essential differences of minerals are contained in their constitution (as in animals and plants in their conformation, which extend to their species); the species of minerals, therefore, should also be classed according to the principle of their essential differences, *i.e.* according to their constitution.

SECT. 11.—To the obstacles which have retarded the advancement of Oryctognosy might be added the want of a correct nomenclature of minerals, arising principally from the introduction of provincial technical terms, or from the use of such as are uncommon or merely invented by authors in relation to their own systems. Several writers also apply false names to many minerals, either from not knowing them or from misunderstanding another writer.

This evil might in a great measure be remedied by attending in every language, in the choice of denominations, to those

Which were the most common;

Which had been employed by the best mineralogists;

Which were the most ancient;

Which were the most usual, where the natural history of minerals mostly flourished, and where the language of the country was best spoken;

Which were most suitable to the nature of the mineral, and best adapted to its distinction;

And lastly, by avoiding in mineralogical translations to render the denominations of minerals otherwise than

by the word usual in the language in which the translation is made.

The name founded on the *nature* of any mineral appears to us the best suited, as it conveys to the mind an idea of the substance itself. Thus, we understand fully the character of *aluminite*, *yttrite*, *magnesite*, *calcite*, *oxide of iron*, &c., whilst we are at a loss to conceive what is meant by *wavellite*, *gadolinite*, *meerschaum*, &c., without previous description.

The objections to other sources whence names might be drawn are these: — The most common names are generally local and indefinite. The best mineralogists (of whom there are many) are often at issue. The most ancient are obviously imperfect, and often incorrect, on account of the state of knowledge at the time. And, lastly, it is rarely that a term or name peculiar to one language can be translated into another, so as to preserve the identity, or make the synonymes uniform and prevalent.—*Wern. Club.*

Sect. 12.—It has also been the practice to consider a mineral as sufficiently described by noticing its constituent principles and its uses, or by classing it here or there according to certain reputed principal characters; and to this cause is to be ascribed the neglect of that perfect and correct description of minerals based on external characters. This has been carried so far, that scarcely any one mineral is to be found in an oryctognostical work, so described that it might be immediately identified and distinguished from others resembling it. Yet this is the most essential part of Oryctognosy; and I would rather have a mineral well described and ill classed, than well classed and ill described. Of this, however, I shall here take no further notice, the external characters of minerals being the immediate subject of this small treatise; to the detailed exposition of which I shall proceed, appropriating only a chapter to the consideration of the characters of minerals in general, and of the pre-eminence of the external characters.

Chapter I.

Of the Characters of Minerals in general, and of the pre-eminence and utility of the External Characters.

Sect. 13.—By "the characters of minerals," we understand all the properties by which we distinguish them from each other, and from other substances. They are as numerous as the different modes of observing them; therefore, we have external, internal, physical, and empirical characters.

Sect. 14.—*External characters* are those which we discover solely through the medium of our senses, in the aggregation of minerals. They are also called sensible characters, the use of our senses being all that is required for their discovery.

Internal characters are those which we discover from the analysis of minerals; and, being discovered by the aid of chemical agents, they are also called chemical.

Physical characters are those which we derive from peculiar physical properties of minerals, and which are observed in the relations they bear to other substances.

Empirical characters are those which, in forming an opinion of a mineral, are deduced from the place of its formation, and from the minerals with which it occurs, which relations are sometimes founded on one of its properties. I have called these empirical characters, inasmuch as they are principally used by those whose knowledge of minerals does not extend beyond that of practical experience.

Sect. 15.—That these four kinds of characters may be very serviceable in the examination of minerals is sufficiently obvious; but the question is, which are principally and peculiarly requisite for that purpose? To determine this inquiry, let us examine:

1. Which of them are present in every species of mineral, and in each individual;

2. Which most certainly evince the essential differences of minerals;
3. Which can be most accurately ascertained and defined;
4. Which can be most speedily and easily discovered; and,
5. Which may be discovered independently of analysis.

Accordingly, I shall now examine each of the four kinds; and it will then appear which is peculiarly related to Oryctognosy.

SECT. 16.—*External Characters.*—1. Are present in all species of Minerals, and in each individual; because they are derived from their aggregation.

2. They certainly evince their essential differences; for since the external characters are derived from the aggregation of minerals, and the aggregation is founded on the attraction of the smallest particles, or molecules, of a mineral, and the different attractions of these particles depend on their different constitution, it follows that as the constitution varies, the mode of aggregation will vary also; and that as the constitution is the foundation of the essential differences of minerals, the external characters will also certainly evince them. Indeed, experience so teaches us; for we find, that as the relative proportion of the constituent principles of any one species varies, and thus approaches nearer to, or even passes into, another, even so do its external characters also vary, and approach nearer to those of the other species. The following may serve as examples :—

1. *Copper pyrites*, in passing into grey copper ore, loses its lustre, the grain becomes much finer, and its greenish-gold-yellow colour inclines a little to steel-grey; passing into white copper ore, its weight and hardness increase, the lustre is somewhat diminished, the grain becomes rather finer, and its colour paler, or inclines a little to whitish; passing into martial pyrites, it becomes harder also, the lustre diminishes, and its yellow colour inclines to reddish instead of greenish. 2. *Grey copper ore*, passing into grey silver ore, increases in weight, becomes softer, and more of

a lead-grey colour. 3. *Calcareous spar*, passing into sparry-iron ore (spathose iron) increases in weight, and becomes yellowish grey. These examples may be sufficient to exhibit the variation of characters in the transitions; and since it occurs even in these, we may safely infer the certain variation of characters in the species themselves. In general, however, similar as many species appear to each other in external characters, it requires only an experienced and attentive observer to discover their distinguishing characters, which are not always prominent; hence it often happens that a mechanic, from mere practice, is much better able to distinguish the minerals that come within his sphere by their external characters, than many a mineralogist.

3. They may be accurately known and defined, because to know and define them, and to observe their number, and wherein they consist, we need only examine the differences of aggregation, which may be easily accomplished by mere attentive observation, particularly as much has been already done in this respect.

4. They may be easily and speedily discovered, because they directly strike the senses, and the other aid is not necessary for their discovery.

5. They may be discovered without analysis, being solely derived from the differences of aggregation.

The two first examples chosen in the text to illustrate the changes produced by the passage of minerals one into another, have not been well selected. Thus, copper pyrites cannot by any possibility pass into grey copper ore without ceasing to be copper pyrites, and becoming a mere mechanical mixture of the two minerals, for the system of crystallisation (and chemical formula of each ore) is entirely different. On the other hand, calcareous spar and spathose iron are really met with in nature in various states of intermixture, without the fundamental form or the chemical formula being altered. This arises from *isomorphism*, a power possessed by certain bodies of uniting in different proportions without affecting the form of the compound. Lime and protoxide of iron being isomorphous, are thus enabled to replace each other in combination without altering the form of the crystal.

The doctrine of isomorphism was first developed by Mitscherlich in 1819, and it immediately shed a new light upon many previously obscure parts of mineralogical science. The dissimilar colours and composition

of the garnets, and different varieties of augite, hornblende, epidote, and other minerals, are owing to this property.—*Wern. Club.*

Sect. 17.—*Internal Characters.*—1. Are present in all species of minerals, but cannot be discovered in every individual, because they are often too small for chemical investigation.

2. They certainly evince the essential differences of minerals, being immediate consequences of their constitution.

3. They cannot be so accurately known and defined as the former, a perfect knowledge of chemistry being requisite, a science not yet perfectly understood.

4. They cannot be speedily and easily discovered, because to discover them many tests and experiments are necessary, often requiring a large apparatus.

5. They cannot be discovered independently of analysis, being derived from that analysis.

Sect. 18.—*Physical Characters.*—1. Are not present in all species of minerals, peculiar properties having been observed in some few only.

2. They do not always evince the essential differences, essentially different minerals possessing often the same property; as amber, and several precious stones, which, when heated, have in common the property of attracting light bodies.

3. Neither can they be accurately known and defined, because the knowledge of them is founded on natural philosophy, even in which their nature is imperfectly known; besides, many properties of bodies are still undiscovered, and can be only gradually brought to light by many and varied experiments.

4. They cannot be easily and speedily discovered, because other instruments and experiments are necessary.

5. They may be discovered independently of analysis, because we need only observe the relation which one individual bears to another with respect to a particular property.

Sect. 19.—*Empirical Characters.*—1. Are not present in all species, and even where they are, not in every individual;

for in respect to the former, many species of minerals are found nearly in all places, and associated with all others; and with regard to the latter, individuals sometimes occur with whose place of formation we are unacquainted, and which are without intermixture.

2. They do not always evince the essential differences of minerals, being too general, belonging most commonly to a whole genus, or at least to the greater part of its species.

3. Neither can they be accurately known and defined; because, 1st, the nature of these properties themselves is as yet unknown; and 2dly, their determination depends entirely on experience, which can be only gradually acquired, and scarcely otherwise than on the spot where they are produced.

4. They can be easily and speedily discovered; and,

5. Independently of analysis, because we need only observe what accompanies or what is mixed with each individual.

Sect. 20.—From the foregoing considerations it follows, that empirical characters are altogether imperfect, tha physical characters are also imperfect, and the discovery o them inconvenient; that internal or chemical characters are tolerably complete aud certain, yet somewhat indeterminate, and their identification attended with the greatest inconvenience, an able chemist being alone equal to the task; besides that, many tests and much apparatus are requisite; each specimen to be detected by means of these characters must be analysed, for which many are unsuitable, and others too small; lastly, that external characters are thoroughly complete, certainly discriminative, best known, easily defined, readily discovered, and hence principally and peculiarly related to oryctognosy.[1]

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[1] Of the three other kinds of characters the chemical appertain peculiarly to mineralogical chemistry, which treats of the analysis of fossils; the physical to natural philosophy, and the empirical partly to mineralogical geography, and partly to geognosy. In the fifth chapter I shall further notice them, as far as some may be applied to the explication of fossils.

That external characters are of the greatest utility in the discrimination of minerals no one can disallow; nevertheless, they are not in all cases sufficient for this purpose, and we ought not, therefore, to refuse the occasional assistance of acids, and especially of the blowpipe — a little instrument which may be packed, with all its necessary apparatus, in a case so small as to be carried without inconvenience in the pocket. It would be easy to point out numerous instances in which, by the employment of external characters only, the beginner might fail in determining the names of particular minerals; but we will content ourselves with a single example, that of carbonate of strontia—supposing the specimen to consist of ill-formed crystals, and so situated that its specific gravity cannot well be taken. By means of the external characters he might separate it from all other minerals, with the exception of sulphate of strontia and carbonate of barytes (witherite); but to distinguish it from these two, in the particular instance mentioned above, he would be compelled to have recourse to chemical characters; for all the three are derivable from the same form—a right rhombic prism—and possess similar degrees of hardness, as well as the same colour, lustre, and general appearance. A drop of diluted acid, however, would at once shew, by the effervescence produced, that it could not be the sulphate of strontia; and the blowpipe would serve equally to distinguish it from the witherite by the deep red tinge imparted to the flame. The acid test might be even omitted, and the blowpipe alone used to point out the absence of a sulphate.—*Wern. Club.*

Sect. 21.—The external characters, therefore, are important to the mineralogist, who, forming from them his external conceptions of minerals, distinguishes and describes each species, even where thousands of individuals occur together, and no other means of examining them are presented than those afforded by the senses, and by them is enabled to ascribe each to its appropriate species. They are very useful, and even indispensable to the chemist, who, if unacquainted with them, could place no reliance on his examinations of minerals, for how is he assured that a specimen is actually of that species which it is his intention to examine, if he does not already possess, by external characters, the correct conception of its exterior? Several instances might be adduced to shew that phenomena noticed by chemists in the analysis of one mineral have been occasioned by the presence of another which they had confounded with it; and whence could this have arisen, otherwise than by the chemists not knowing how

to distinguish their subjects oryctognostically, *i.e.* according to external characters? Lastly, a knowledge of external characters is productive of no small advantage to the miner, enabling him immediately to form an opinion of every fresh appearance or discovery in the mine, which he has rarely an opportunity of examining chemically, which, indeed, is always attended with inconvenience and difficulties. In separating and dressing ores, he can have no other mode of distinguishing them than by external characters, an advantage enjoyed by every one employed in mineral industry.

Chapter II.

History of the External Characters of Minerals.

Sect. 22.—The most ancient writers on mineralogy, as *Theophrastus*,[1] *Pliny*,[2] and others, described minerals with regard to their use only on this account, they make little mention of their external characters, and only occasionally employed them to assist in their descriptions.

Sect. 23.—For many centuries after their time there was not any professed writer on mineralogy, and the science itself had become almost wholly extinct; it is not to be wondered at, therefore, that nothing particular appeared respecting the external characters of minerals.

Sect. 24.—At length *George Agricola*, the father of Metallurgy, produced among other valuable works his treatise "De Natura Fossilium."[3] He was the first who introduced the proper use of external characters as applied to the distinction and description of minerals; for which purpose he has in the beginning of his work drawn up a system of external characters, and furnished the following notices:—

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[1] Theophrasti Erisii *περὶ τῶν λίθων βίβλιον.*

[2] Caii Plinii Secundi Historia Mundi, lib. xxxvii.

[3] Georgius Agricola De Natura Fossilium. Basileæ, 1546. Folio. I pass by preceding mineralogical writers, as Avicenna, Albertus Magnus, &c. as their works do not contain anything worthy of note respecting external characters.

1. The Appearance,

the colour	*color*
the transparency	*facilitas translucida*
the resplendence	*fulgor*
the lustre	*nitor.*

2. The Taste,
3. The Smell.
4. The Touch.

the cold and warmth	*frigus et calor*
the moisture and dryness	*humor et siccitas*
the greasiness and meagreness	*pinguitudo et macritudo*
the compactness and porosity	*spissitudo et raritas*
the hardness and softness	*durities et mollitudo*
the roughness and smoothness	*asperitas et lævor*
the weight and lightness	*gravitas et levitas.*

Besides these, he reckons the following among the particular properties of minerals, by virtue of which they are either passive or active :—

the viscidity	*lentor*
the flexibility	*flexibilitas*
the friability and fragility	*friabilitas et fragilitas*
the thickness and thinness	*crassities et tenuitas*
the ductility	*tractabilitas*
cleaving	*fissio*
the fissures	*fissa.*

At the end of his work he also particularly notices the shape and size of minerals :—

The Form.

1. Indeterminate,
2. Tabular,
3. Round,

perfectly globular	*figura globi absoluti*
compressed globular	*f. globi compressi*
semi-globular	*f. globi dimidiati*
cylindrical	*f. cylindrica*
conical	*f. metæ*
turbinated	*f. turbinis.*

4. Angular.

triangular	*figura triangula*
quadrangular	*f. quadrata*
pentangular	*f. quinque angulis*
hexangular	*f. sexangula*
polyangular	*f. pluribus angulis*
acuminated	*cum mucrone.*

5. Resembling other bodies:

horns	*f. cornu*
the moon	*f. lunæ*
hairs	*f. capillorum*
the ears	*f. auricularum*
cells	*f. favarum*
lentils	*f. lentium*
the trunk of a tree	*f. arboris trunci similis*
darts	*f. sagittæ*
acorns	*f. glandis.*

6. Appears in the fracture or internally.

7. Marked with lines, and resembling

eyes	*f. oculi*
stars	*f. stellarum*
fishes	*f. piscium*
animals	*f. animalium*
mountains and valleys	*f. montium et convallium.*
bushes	*f. nemorum*
rivers	*f. fluminum.*

The Magnitude.

He has mentioned the differences of each of these characters, and added examples by way of illustration. Although *Agricola* has done as much in this system as could be possibly expected from him at that time, it is, nevertheless (being the first attempt of the kind), very imperfect; many external characters are wanting, and several noticed which are not properly characters. Besides, they are neither arranged in a good order, nor defined by explanations. His descriptions of minerals are also very incomplete.

Sect. 25.—After *Agricola* two centuries elapsed in which nothing particular occurred with respect to external charac-

ters, except that some mineralogists applied them to the classification of minerals, particularly of earths and stones. It so happened that these mineralogists were also botanists and zoologists, and therefore wished to introduce into mineralogy the same methods as obtained in botany and zoology. Among these *Gesner*[1] and *Scheuchzer*[2] may be particularly noticed, who have had many followers.

SECT. 26.—When at length mineralogy in general, and oryctognosy in particular, began to flourish, among the many publications that appeared on this science there were several which treated either partially or wholly of external characters. The first particular treatise on this subject was that of Professor *Hausen*, in the year 1737;[3] but as the author had solely the classification of minerals in view, the greater part of the characters are only noticed in an incidental manner, and merely the lustre, structure, and parts into which fossils divide in breaking, are considered in detail, as adapted to his purpose. It appears to me, however, that his distinctions are oftentimes not sufficiently discriminative, and at other times too subtle.

SECT. 27.—*Wallerius* was the first, in his "Mineral-ricket,"[4] published in the year 1747, to give more complete descriptions of minerals, according to external characters, than any hitherto published; and of the number of mineralogists who succeeded him, some are to be met with (among whom *Cartheuser*[5] and *Bomare*[6] deserve particular notice), whose descriptions are still more complete; and since their time oryctognostical works are generally much improved. But we may still object to the descriptions of both: 1st, Because they are incomplete, specific characters being wanting;

[1] Conr. Gesnerus de figuris lapidum.—Tiguri, 1565–4.

[2] Joh. Jac. Scheuchzer, Meteorologia et Oryctographia Helvetica.—Tiguri, 1718–4.

[3] Chr. Aug. Hausenii Prog. ad solennia promotion.—Magist. Lipsiæ, 1737-4.

[4] Joan Gottsch. Wallerii Mineral-ricket.—Holm. 1747, 8.

[5] Frid. Aug. Cartheuseri Elementa Mineralogiæ, Frf. ad Viadr. 1755–8.

[6] Valmont de Bomare, Minéralogie, à Paris, 1762–8.

2dly, Because they are not sufficiently distinct and defined; neither of these mineralogists having previously arranged the external characters in a system, to serve as a constant guide in description; nor having previously defined and explained them, so that each character might be clearly understood; 3dly and lastly, Because both have often used the same term to describe dissimilar characters.

SECT. 28.—The second work, which treats in particular of this subject, was published by Dr. *Gehler* in the year 1757, being a dissertation "De Characteribus Fossilium externis." The author has thus classed them after the five senses:—

1. The Smell,	
arising spontaneously	*sponte enascens*
arising from attrition or combustion	*attritu* s. *deflagrando enascens.*
2. The Hearing.	
the crackling	*crepitus*
the ringing	*sonus quem edunt percussi.*
3. The Taste.	
4. The Touch.	
smooth and rough	*læve et asperum*
greasy and meagre	*pingue et macrum*
friable and solid	*friabile et densum*
light and heavy	*leve et grave.*
5. The Sight.	
the colour	*color*
the size	*magnitudo*
the specific gravity	*gravitas specifica*
the ductility and fragility	*ductilitas et fragilitas*
the transparency and opacity	*pelluciditas et opacitas*
the hardness	*durities*
the external shape	*figura seu forma.*

SECT. 29.—As yet *Agricola* had been followed by *Linnæus* alone, who, in the last much-improved edition of his "Systema Naturæ,"[1] when treating of mineralogy, considered and

[1] Caroli a Linné Systema Naturæ. Holmiæ, 1768. 8vo. Tom. iii. pp. 29, 30.

defined most of the characters, of which he afterwards makes use.

But the order, if such it may be called, in which they are arranged, is not praiseworthy, and the list is not complete, many characters being deficient; besides, most of them are too concisely drawn, and are therefore obscure and unintelligible; and lastly, examples, which are so serviceable in rendering them clear and intelligible, are wanting. The following are the external characters which *Linnæus* treats of in his "Mineralogy:"—

1. The External Form.

of an indeterminate form	*amorphum*
crystalline	*crystallinum*
cubical	*tessellatum*
prismatical	*prisma*, s. *columna*
pyramidal	*pyramis*
lenticular	*lentiforme*
nodular	*nodulosum*
kidney form	*reniforme*
even	*planum*.

2. The Coating.

shelly	*crustosum*
cortical	*corticosum*
concentric	*concentricum*
kernelly	*embryo*

3. The Surface.

superficial	*superficiale*
rough	*scabrum*
smooth	*læve*
shining	*nitidum*
glimmering	*micans*.

4. The Particles.

compact	*compactum*
impalpable	*impalpabile*
dusty	*pulverulentum*
arenaceous	*arenosum*
granular	*granulatum*.

5. The Fibres.

fibres resembling ears of corn	*acerosum*
interlaced fibrous	*decussatum*
parallel fibrous	*fibrosum*
scaly	*squamosum.*

6. The Structure.

foliated	*membranaceum*
fissile	*fissile*
diverging from the centre	*concentratum*
consisting of fragments	*fragmentis.*

7. The Hardness.

striking fire	*scintillans*
capable of being scraped	*rasile*
firm	*durum*
fragile	*fragile*
sectile	*sectile*
friable	*friabile*
brittle	*rigidum*
flexible	*flexile*
malleable	*malleabile*
staining	*inquinans*
staining and marking	*inquinans scriptura*
giving a streak	*inquinans tritura*
giving a white streak	*tritura alba*
giving a red streak	*tritura rubra*
giving a black streak	*tritura nigra.*

8. The Colour.

opaque	*opacum*
semi-transparent	*diaphanum*
transparent	*pellucidum*
colourless	*hyalinum*
coloured	*tinctum*
reflects the rays	*reflexio*
refracts the rays	*refractio.*

The reputation of *Linnæus* has been enhanced by his exact determination of the crystallisations of minerals, nearly all of

which, before his time, if not as obvious as the cube, were called polyhedral; it were only to be wished that succeeding mineralogists had taken the proper advantage of the pains bestowed on this subject.[1] The author treats of crystallisation at the end of his Mineralogy, and determines them in a three-fold manner: 1. by giving the *number* and *form* of the sides of a crystal; 2. by bringing all crystals under two principal genera, one of which he calls *prismatical* (columnæ), namely those whose form extends in length; the other *cubical* (tesseræ), being those whose form is generally of equal length, breadth, and thickness, and consequently presents a square or even globular appearance; 3. by endeavouring to compare all crystals with those of salts, and accordingly as they agree with one or the other, appropriating to them the same name. The author mentions five kinds of known salts, under which, on account of their coincidence in figure, he arranges most of the crystallisations of the mineral kingdom; these are *natron*, *nitre*, *alum*, *common salt*, and *vitriol*. Those crystals which cannot be brought under any of these salts the author supposes to appertain to, and to have received their form from, a peculiar kind of salt as yet unknown.[2] Though it is so far useful to compare the crystals of minerals with those of known salts, the description of the former being thereby rendered more clear and intelligible, I nevertheless entertain many doubts of the truth of the position, that the salt which coincides in figure with any crystal should be the cause of the figure of this crystallisation.

With respect to the descriptions of minerals according to external characters, I find it necessary to observe in this place what I have already said of all others, that they are still very incomplete.

The strange theory of Linnæus that all crystals contained one of the salts mentioned in the text, and to the presence of which their particular

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[1] It is but justice to remark, that when this was written Werner was unacquainted with the ingenious and elaborate "Crystallographie" of Romé de l'Isle, of which the first edition appeared in 1772.

[2] C. a Linné Amœnitates Academicæ. Vol. I. Dissert. de Crystallorum Generatione. Respond. Martino Kachler. Holm. 1750–8.

forms were due—"Crystallus lapidea sal non est, sed continet sal, cujus figuram gerit, &c."—met at the time with considerable approbation. Linnæus, however, cannot be termed the original inventor of this theory, as we find Dr. Woodward, an English author, in his "Attempt towards a Natural History of the Fossils of England; London, 1728–9," promulgating an opinion of a similar kind, and making quartz the universal agent of crystallisation. This substance, he fancied, when combined with iron, produced a rhombic figure; when with tin, a quadrilateral pyramid, and so on. Linnæus, some years afterwards, in taking up this theory, substituted his own peculiar salts for the rock crystal of Dr. Woodward.

It is, perhaps, needless to add, that these views have not the least pretensions to truth; they could, in fact, only exist in the very infancy of chemical knowledge. Crystallisation is now known to be a natural and independent power, inherent in all inorganic matter, or rather in all matter subject to inorganic laws. We abstain from entering more fully into the modern doctrine of crystallography and its applications to mineralogical science, until we reach that part of the work especially devoted by Werner to a consideration of the forms of minerals.—*Wern. Club.*

SECT. 30.—*Peithner*[1] and *Hill*[2] are the first, in their systems of mineralogy, who have attempted a tabular arrangement of those external characters, by which they would communicate the exterior of a mineral.

For this purpose *Peithner* employs seven columns, of which, however, the one or the other, when superfluous, is omitted in several of the tables; the first of these columns contains the *colour*, the second the *transparency*, the third the *form*, the fourth the *taste*, the fifth the *smell*, the sixth the *weight*, the seventh *internal properties* and *effects*, discovered by different experiments; in which latter are also frequently placed several external characters, which cannot be brought under the preceding, as the *hardness*, the *solidity*, the *streak*, the *stain*, and others. Before these columns the author places the names of the varieties to be described, and which are already arranged in a system, following each

[1] Joh. Thad. Peithner's Erste Gründe der Bergwerkswissenschaften, und Abhandlung über die Mineralogie. Prag. 1770–8.

[2] J. Hill. Fossils Arranged according to their Obvious Characters. London, 1771–8.

other in a natural order; in the columns themselves are placed, in a line with the name of the mineral and under the above-mentioned heads, those external characters which constitute its exterior. But here I must observe, that the external characters employed by *Peithner* for the determination of minerals are not sufficient to impart complete external conceptions of them; that these external characters should have been previously explained, in order to ascertain the exact idea which the author attaches to each; that the order in which they are arranged is not the best; and lastly, that under one head, instead of the proper character, another is very often placed, which does not at all belong to it, as *e. g.* under transparency—the lustre; under form—the structure.

In *Hill's* "Mineralogy" the external characters are arranged in six columns, of which the first contains the *form*, the second the *hardness*, the third the *weight*, the fourth the *surface*, the fifth the *colour*, the sixth *particular properties;* in which latter also are usually placed, the *transparency*, the *smell*, the *taste*, or some other external character which could not be brought under the foregoing heads; and those external characters which are to convey the external conception of a species are always placed in the columns in a line with each other, and above is the name of the species. The author, however, employs too few external characters to impart perfect descriptions of their exterior; besides, they are too indeterminate, and very ill arranged. Characters are also frequently placed under one head which do not belong to it, and sometimes such as are no characters at all—*e. g.* that the species constitutes entire mountains, or occurs in beds or layers, and yet the author places these, a feature not to be learned from any specimen, under the head of the external form.

This method, however, if brought to perfection, would not be without its use, for it would constantly direct us to the observance of one and the same order in all descriptions; and the determination of the external characters might be rendered much more concise. This object has been attained by both these authors, and their works are, therefore, prefer-

able to all those which have preceded or followed them. On the other hand, there are several inconveniences; the tables, if made more complete, and consequently more extensive, would require a much larger, nay, too large a form, and frequently, where a more copious expression would be necessary, space would be wanting: whereas it is my firm conviction, that with regard to descriptions, it is much better to be diffuse in expression than, for the sake of brevity, to prove obscure and unintelligible.

Sect. 31.—Very recently *Wallerius*[1] (of whom we have already had occasion to make mention) has produced his "Systema Mineralogicum," which we may pronounce to be the most complete that has hitherto appeared, not only as to mineralogy in general, but particularly in the description according to external characters. Yet I must still observe, that in his external descriptions external characters are frequently wanting, and that the external characters contained in the descriptions are neither well arranged nor sufficiently defined.

Chapter III.

Of the Definition of the External Characters of Minerals.

Sect. 32.—The definition and classification of external characters have been already given in the first chapter. It has also been shewn that the external characters are preferable to all others, and peculiarly appertain to oryctognosy. But to apply them to the description of minerals, and to identify by the external or oryctognostical knowledge of them necessarily requires *that they be defined as accurately as possible.*

Sect. 33.—For how can a student in oryctognosy obtain correct external conceptions of minerals from description, if unacquainted with the true meaning of the different external characters which are the foundation of those descriptions?

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[1] Joh. Gottsch. Wallerii Systema Mineralogicum. Holmiæ, 1772-8.

This indefiniteness is increased when oryctognostical writers bestow different denominations on the same character, so that two different persons frequently form very different ideas of the same denomination; nay, sometimes a mineralogist applies several denominations to the same character, or the same denomination to different characters. This indefinite application is the principal cause of the imperfection of external characters, and of the consequent inutility of descriptions; on the contrary, the descriptions would be perfect had the external characters been as well defined as they are well arranged and complete. The method of teaching mathematics owes great part of its perfection to the exact definition of terms, for here all connect the same ideas with a sum, a line, or an angle, and again all apply the same denomination to one idea. If, then, mineralogists would unite with a view to render oryctognosy, in this respect, as nearly similar as possible to mathematics, what advantages might not this science derive from their endeavours!

SECT. 34.—*The definition of the external characters of minerals in general*, requires,—1st, that we understand what are external characters; 2d, their number; 3d, that we apply to each an appropriate and determinate signification; 4th, that we give a proper and adequate conception of each; and 5th, that we endeavour to shew the relations in which they stand to each other.

SECT. 35.—*What external characters are*—may be found in the commencement of the first chapter of this treatise. The description there given of them will enable us, in every description according to external characters, to divest it (in order to render it the more clear) of whatever does *not* belong to it.

SECT. 36.—*The number of external characters* may be learned,—1st, by collecting all those which have hitherto been made known and employed by oryctognostical writers; and 2d, by discovering in minerals themselves those which have remained unobserved. In the system contained in the annexed tables, and which I shall follow in due course, I

have endeavoured to determine their number as precisely as possible. It is on this accuracy as regards number that the completeness of the external descriptions or external conceptions depends; for if a correct external conception of a mineral is to include every difference perceptible by the senses (and these are its external characters) the conception will be incomplete if it do not include *all* the differences which distinguish it from others, or may distinguish it from those yet unknown : but how can a mineralogist be assured that an external conception communicated by him through description, includes all the external characters, if unacquainted with the *number* which it is possible to discover? As, on the one hand, the conception of what external characters are, ensures to us the certainty of not saying too much in descriptions founded upon them; so, on the other hand, the knowledge of their *number* will obviate the possibility of saying too little.

SECT. 37.—A character is appropriately described if it fully express its quality, and all that distinguishes it from others of its species or genus, and is determinate, if it be the only one applied to one character. Care in the choice of the former is the more necessary, as it is in some measure the foundation of the latter. Where the denomination is merely optional, it will be sufficient to adopt such as are in most common use with eminent mineralogists; andthe denomination should always be written according to the best idiom of the language. These are the rules which I shall myself follow in giving denominations to characters; I shall not fail, however, to notice in their proper places such as are defective or synonymous. The advantages which result from appropriate and determinate denominations, and the uncertainty and confusion which proceed from the contrary, have already been sufficiently shewn in Sect. 33.

SECT. 38.—The adequate conception of an external character may be conveyed by a correct and clear description. But as this is attended with some difficulty, being frequently intimately connected with each other, it is useful to analyse the complex characters, in order to render them as simple as

possible, and then to explain the simple characters only. Complex external characters are such as consist of two or more simple characters, as, *e. g.* scorious; here conchoidal fracture is united with lustre: specular; here, strong lustre is combined with an even surface: vitreous, when lustre is connected with transparency and splintery fracture. And as all the simple characters of which the complex consist are in their own nature transitory or passing into others, as, *e.g.* lustre which passes into dulness, splintery into even, and this again into conchoidal; this difficulty is considerably increased when many such simple characters are complicated in one.[1] Well-selected illustrative examples materially assist description, and are those in which the character to be illustrated does not pass into another nearly allied to it; as in the fibrous, where it passes into the striated or into the compact; but, on the contrary, in which it is best and most clearly to be perceived. We should also in these explications cautiously avoid employing brevity at the expense of perspicuity.

In describing the external characters which are systematically contained in the following chapter, I shall, as far as possible, exhibit simple characters only (such, however, as are complex I shall notice in their proper places); and in every description I shall, if practicable, adduce at least three illustrative examples of the character to be explained.

The advantages which good explications, accompanied by illustrative examples, afford to the definition of the external characters, and to the consequent intelligibility and utility of the descriptions of fossils founded on these characters, have already been sufficiently shewn, and are in themselves so obvious, that to make any further comment would be unnecessary.

SECT. 39.—The relations of external characters to each other are best seen by classing them in a correct system, *i.e.* by distributing them into their genera and species, and arranging these according to their natural order. Genera of external characters, or generic characters, are those which

[1] The proper course to be pursued in descriptions with complex characters will be pointed out in the 5th Chapter.

direct us to what is to be determined in a mineral; such are colour, cohesion of the particles, weight, taste, &c. Thus, in saying copper pyrites has a colour, I have not determined anything, but merely pointed out what is to be determined. Again, generic characters are common and particular; common when they point out what is to be determined in every mineral and particular, when that which is to be determined exists in one class only. Of the former, those adduced above may serve as an example; .of the latter, we may notice solidity, sound, &c. which are solely applicable to one class, viz. the solid. Species of external characters, or specific characters, are those which determine what may be said of a mineral with respect to generic character; as, *e. g.* in saying that copper pyrites, with respect to colour, is yellow, or with respect to hardness, is half-hard. It is from these specific characters that we form the external conception of a fossil, and that we frame its external description; whereas the generic characters serve merely to class the former under genera, and to indicate those for which we are to seek. Lastly, varieties are those by which a mineral is accurately determined with respect to a specific character, as, *e. g.* in saying that copper pyrites is brass-yellow, or that the diamond, in respect to hardness, is extremely hard; for since specific characters have often several varieties, and minerals are frequently distinguished merely by one variety, it becomes necessary, in order to determine a mineral with respect to one or other generic character, not only to mention the specific character, but also the variety.

An arrangement of all these external characters according to a natural order necessarily requires a previous determination of the natural order; but as the external characters are all those differences or distinctions which we perceive by means of our senses, their most natural order will of course be that in which these distinctions present themselves to our senses, and become subject to observation. According to this principle all generic characters should be arranged. But to determine the order of the specific characters and their varieties, as they belong to one or the other generic

character, we must seek some other principle; and this will not be difficult to discover, if we consider their nature. For as all specific characters are merely differences or varieties of a generic character, that order will surely be the most natural in which the generic character varies, and in which they pass one into the other. This also holds good with respect to the varieties of specific characters.

Therefore, in a system of the external characters of minerals, all the varieties will be arranged under their species, the corresponding species under their common or particular genera, and the particular genera under the one or the other common genus to which they belong; secondly, all genera or generic characters will follow each other in the order in which they present themselves to our senses, so that those which the eye observes stand first; for we much sooner see a mineral than examine it by the touch, or any other sense. Among these, again, colour will occupy the foremost rank, as we much sooner perceive and distinguish colour than external form, &c. Again, after those which strike the eye, those will follow which are observed by the touch; and lastly those which belong to the smell or the taste. Thirdly, all specific characters and varieties will follow in the order of their transitions, or in which they pass one into the other; as, *e. g.* in the fracture, to the fibrous will succeed the striated, the foliated, the slaty, and then the compact. It is in conformity with these principles that I have composed my system of external characters, contained in the annexed tables.

The advantage of such a system is, in general, to make us better acquainted with the nature of external characters, and to render them intelligible; and in particular, to serve as a guide in forming external conceptions of minerals, and in framing descriptions founded upon them, by which the discovery of the external characters is not only facilitated, and the possibility of omitting any one prevented, but also in the description itself the one often elucidates the other, and greatly assists in retaining the conceptions.

Sect. 40.—As I believe my readers have been suffi-

ciently informed in what external characters consist, how they should be explained, and the existing deficiency in this respect, I shall now proceed to the explication of each in particular.

The Generic Characters of Minerals.

1. Colour.
2. Form or cohesion of particles.

		Solid.		Fluid.
		Solid.	*Friable.*	
Characters for the sight.	External	External form	External form	External form
		External surface		
		External lustre		
	Internal	Internal lustre	Lustre	Lustre
		Fracture	Appearance of particles	
		Form of fragments		
		Transparency		Transparency
		Streak		
		Stain	Stain	
For the Touch.		Hardness	Friability	Fluidity
		Solidity		
		Frangibility		
		Flexibility		
		Adhesion to the Tongue		
Sound.				

Remaining Generic External Characters.

3. Unctuosity.
4. Temperature.
5. Specific gravity.
6. Smell.
7. Taste.

Chapter IV.

Explication of the External Characters of Minerals.

I. The Colour.

Sect. 41.—Among common generic characters colour is the *first* which strikes the senses. It is also one of the most certain characters, serving as a principal distinguishing mark

of most ores, inflammable substances, and salts. Who does not know how easily native gold, native silver, vitreous and corneous silver ores, copper pyrites, vitreous copper ore, specular iron ore, sparry iron ore, galena, tin-stone, sulphurated bismuth, striated red cobalt ore, arsenical and martial pyrites, natural sulphur, pit-coal, mineral pitch, aluminous shale, &c. are distinguished by their colours; besides many others named from their colour, as red silver ore, red, green, and white-lead ores, brown iron-stone, blue martial earth, red antimonial ore, yellow blende, grey cobalt ore, &c. Although colour is less to be depended upon in earths and stones, it nevertheless distinguishes most of them. Various species of silex are readily distinguished by it, as also the muriates distinguished by their green, or greenish-white colour; and likewise swine-stone, by its brown colour, which is a transition from light to dark brown; not to mention many others.

Those mineralogists, then, are in error who consider colour as an uncertain distinctive character; it is true that it is not sufficient in itself to distinguish minerals from each other, but this holds good with *every* external character, and it is only the sum total of all possible external characters that constitutes the distinctive conception of its exterior.

The reason that colours in earths and stones are sometimes so variable, is, that their primitive colour is properly white, as of inflammables it is black, and of metals variegated; and as white is that colour which, by reason of its clearness, is most easily and evidently changed by a trivial admixture of a substance of another colour; it happens that whenever only a small portion of inflammable or metallic particles enters into the constitution of earths or stones, their colours are directly changed to brown, red, yellow, green, blue, &c. Whereas metals, on the contrary, scarcely become lighter from a slight admixture of earth, or darker from a small portion of inflammable matter.

In allusion to "the various species of silex" of our author, it may be observed that, in the writings of all the older mineralogists we invariably find the different kind of quartz—as rock-crystal, rose-quartz, prase, chrysoprase, chalcedony, &c., now shewn to be merely varieties of one substance, silica—raised to the rank of distinct species, and treated separately as such. At first sight, it naturally appears strange to persons unacquinted with the science, that two minerals, or even

three or four, of totally opposite colours, should be called by the same name. Let them reflect, however, that if they were presented with a red, a purple, and a yellow dahlia, they would not hesitate for a moment to give to each flower the same denomination.—*Wern. Club.*

SECT. 42.—To be exact, colour is that property of a mineral which, by reason of the figure, or association, of its molecules, causes a different refraction of the incident rays of light, producing a different sensation in the eye.

The colours which are observed in all ordinary substances have been distinguished into certain *principal colours;* all those which are in some degree connected with each other having been brought under one genus, and the *generic name* of the principal colour having for the greater part been added to the *distinctive name* of the species, as, *e.g.* gold-yellow, grass-green, brownish-red. To ascertain, therefore, the number of primary colours, and to which of these each variety belongs, we need only attend to the different generic names. There are *eight* primary colours: *white*, *grey*, *black*, *blue*, *green*, *yellow*, *red*, and *brown*.

SECT. 43.—The colours which are subordinate to these eight primary colours vary much in proportion to their intermixture.

In order, therefore, to define these different varieties of the principal colours, we must give to each a *determinate* and *systematic* denomination, arranging it accordingly as it passes into others in relation to its composition; we must then determine the composition itself, and lastly corroborate and elucidate the description by appropriate examples, either from the mineral kingdom or other substances. Flowers possessing *fixed* colours might serve as good examples.

SECT. 44.—A denomination is *systematic* when it not only distinguishes the subject from other species, but also expresses the genus to which it belongs, thereby uniting the generic name to that of the species, as, *e. g.* bluish-black, scarlet-red, sky-blue.

The generic names of colours are *determinate*, being the names of the primary colours. But the specific denominations, or the names of the species, are selected variously: sometimes they are borrowed from ordinary substances, as,

e. g. milk-white, *sky*-blue, *canary*-green, *liver*-brown; to which those belong which are derived from the metals, as, *e. g. silver*-white, *steel*-grey, *gold*-yellow; sometimes they are taken from a simple or compound pigment, as, *e. g. indigo*-blue, *azure*-blue, *verdigris*-green; and sometimes they are derived from the primary colour to which that to be denominated approaches by an admixture with it, as, *e. g. bluish*-grey, *yellowish*-brown. It is very rarely that a proper name is chosen, as, *e. g. Isabella*-yellow.[1]

With respect to denomination, I will only remark, that those derived from metals are solely applied to metallic bodies.

SECT. 45.—The composition of the varieties of colours is determined by shewing their constituents, and the relation in which these stand to each other with respect to intensity. This may be done by means of a few determinate expressions employed in pointing out the constituent colours. These are—that the predominating constituent colour, in consideration of which the mixed colour has been brought under one or the other principal colour, is, as the generic denomination, placed last; and that which has principally altered it is, as specific, prefixed to it with the relative termination *ish*, as, *e. g.* bluish-black, reddish-yellow, brownish-red: if, however, the latter be but slightly mixed with the former, or, besides the two usual colours, a third enters slightly into the composition, the expression "inclining to" is employed; or, if more intense, "verging on," as, *e. g.* blue inclining a little to reddish, yellowish-green inclining a little to brown, red verging on yellow.

SECT. 46.—Colours may be further determined by the relation in which they stand to each other with respect to shade. Thus, the shades of principal colours differ; for we have light colours, as white and yellow, and dark, as blue and black. Further, the varieties subordinate to each principal colour differ from each other in respect to shade, as, *e. g.* among the blue colours, indigo-blue is dark, azure-blue clear, and sky-blue light; and even each variety may be

[1] Some of these distinctive names are now out of date.

distinguished with regard to shade, as, *e.g.* clear canary-green, light canary-green. In general, however, four degrees may be adopted to distinguish the shade of colours, expressed by the words, dark, clear, light, pale.

The shade of colour frequently simply depends on transparency, the paleness of a colour being in proportion to the degree of transparency, and the darkness in proportion to its opacity. Hence several transparent minerals possess so pale a colour, that several writers have described them as colourless, *e.g.* rock-crystal, diamond, specular-gypsum. In this, however, an error is committed, rendering the descriptions inaccurate; for every mineral, according to our opinion, necessarily possesses a colour, which may be easily discovered in those described as colourless, by merely comparing them with each other.

The greater or less degree of lustre has also an influence on the shade of colour in minerals.

1. *The Principal Colours, with their varieties.*

White —	Snow-white,	*Blue* —	Indigo-blue,
	Reddish-white,		Prussian-blue,
	Yellowish-white,		Azure-blue,
	Silver-white,[1]		Violet-blue,
	Greenish-white,		Smalt-blue,
	Milk-white,		Sky-blue.
	Tin-white.[1]	*Green* —	Verdigris-green,
Grey —	Lead-grey,[1]		Mountain-green,
	Bluish-grey,		Emerald-green,
	Smoke-grey,		Grass-green,
	Yellowish-grey,		Olive-green,
	Steel-grey,[1]		Blackish-green.
	Ash-grey.	*Yellow* —	Sulphur-yellow,
Black —	Greyish-black,		Lemon-yellow,
	Brownish-black,		Gold-yellow,[1]
	Dark-black,		Bell-metal-yellow,
	Iron-black,[1]		Straw-yellow,
	Bluish-black.		Wine-yellow,
			Ochre-yellow,

[1] These are *metallic* colours, to which Chapman, in his work on External Characters, has added *bronze yellow*.

	Orange-yellow.		Flesh-red,
	Brass-yellow.[1]		Brownish-red.
Red —	Aurora-red,	*Brown* —	Reddish-brown,
	Hyacinth-red,		Clove-brown,
	Brick-red,		Hair-brown,
	Scarlet-red,		Yellowish-brown,
	Copper-red,[1]		Tombac-brown,[2]
	Blood-red,		Wood-brown,
	Carmine-red,		Liver-brown,
	Crimson-red,		Blackish-brown.

Sect. 47.—I will now explain each principal colour and its varieties, according to the order of transition. Among these white occupies the first place. In natural philosophy it is considered as pure light, as being the undivided solar ray. To prove this from experiments would lead me too far from my subject; whoever wishes to certify this may find them at large in most books treating of natural philosophy. White is the clearest of all principal colours; and hence, in comparison with the rest, admits but a slight admixture of another colour. I have already remarked, in the note to Sect. 41, that white (the metallic white excepted) appertains peculiarly to earths and stones. We have,

1. *Snow-white.* This is white proper. It occurs in snow-white quartz, acicular white-lead ore from Glücksrad, near Zellerfeld, white coralliform stalactite from Styria, limestone from Carrara.

2. *Reddish-white.* Here white is mixed with some little red, and through this variety passes into the red. It is found in porcelain earth, reddish-white calcareous spar, reddish-white quartz.

3. *Yellowish-white.* In this variety, white is mixed with some little yellow, and through it passes into yellow. Many call it also milk-white because it is the colour of thick cream. It is present in white-amber, yellowish-white stalactite, zeolite, chalk.

4. *Silver-white.* This is metallic white inclining a little to yellow. Its name is derived from silver, to which it pro-

[1] See note in preceding page.
[2] Werner considers this a metallic colour—*seq.*

perly and peculiarly belongs. We meet with it in native silver, native bismuth, arsenical pyrites.

5. *Greenish-white* is white mixed with some green, forming the transition from white into green. It is found in talc, white amianthus, and the calcareous spar resembling talc, from the mine Unverhofftes Glück, near Schwarzenberg in Saxony, limestone from the Alte Berg near Schmalzgrube.

6. *Milk-white* is white mixed with some blue. Its name is borrowed from skimmed milk, to which this colour particularly belongs. It is present in opal and milk-white quartz.

7. *Tin-white* is metallic white inclining a little to blue. It constitutes the transition from white into lead-grey. Its name is derived from tin, in which this colour peculiarly occurs. In the mineral kingdom, we meet with it in white cobalt ore, native quicksilver, arsenicated native silver, and native-antimony.

An instance was cited in the "Analysis of the Natural System, and its Application to the Mineral Kingdom," p. 29, published by the Wernerian Club, where quartz, which is white when pure, assumes various colours from the admixture of other ingredients. "It is therefore interesting to trace the agency of foreign ingredients in the effects which they produce." See also Note to Sect. 41.—*Wern. Club.*

Sect. 48.—Grey, the second principal colour, proceeds from a mixture of white with a little black; hence it constitutes the transition from the one colour into the other. Consisting for the greater part of white, it is one of the palest of the principal colours.

The several varieties of grey arise accordingly as a slight admixture with another principal colour takes place. They are the following:—

1. *Lead-grey.* This is a metallic bluish-grey, appearing to consist of steel-grey, with a slight admixture of azure-blue. Its name is borrowed from lead, to which this colour peculiarly belongs. It is one of the most common in the mineral kingdom, and occurs in common galena, compact galena, sulphurated bismuth, grey antimonial ore, vitrous copper ore, molybdæna from Altenberg in Saxony.

2. *Bluish-grey* differs from the preceding in want of metallic lustre only. It is found in bluish-grey clay, bluish-grey limestone, and bluish-grey marl.

3. *Smoke-grey* is composed of a rather dark grey, with a slight admixture of blue and very little brown. Derived from smoke, which is generally of this colour, it is found in dark-grey flint, grey crystallized calcareous spar, grey hornstone, and grey fluor spar from Freyberg.

4. *Yellowish-grey* is a pale grey mixed with more or less yellow. It occurs in yellowish-grey argillaceous iron-stone from Wehrau in Upper Lusatia, yellowish-grey tripoli, yellowish grey chalcedony, yellowish-grey indurated earthy lead ore, from the mine Rauten Kranz near Johangeorgenstadt.

5. *Steel-grey*. This is a metallic blackish-grey colour, and which seems to possess a greater portion of black than either of the other grey colours; hence it constitutes the transition from grey into black. Derived from steel, to which it properly belongs, it is very common in the mineral kingdom, in specular iron ore, striated grey ore of manganese, grey copper ore, grey cobalt ore.

6. *Ash-grey* is one of the rarest and the purest of the grey colours, consisting of yellowish-white and black, and derived from wood-ashes not burnt white, to which this colour properly belongs. It occurs the most distinct in wacke graduating into basalt, also in argillite.

SECT. 49.—*Black* holds the third place among the principal colours; it is considered as the total absence of light. This colour occurs very frequently in the mineral kingdom, and appears chiefly peculiar to inflammable substances; it is the darkest of the principal colours, and on this account the admixtures of other colours are not easily perceived. The few varieties which it possesses, and which proceed from an admixture of other principal colours, are difficultly distinguished from each other: they are the following:—

1. *Greyish-black*. In this variety black is mixed with grey; it is also the transition from black into grey, viz. into blackish-grey. Of this colour we have black flint, hornblende, argillite, black limestone, basalt.

2. *Brownish-black.* Here black is mixed with brown, and passes through it into blackish-brown. We meet with this colour in wolfram, black blende, bituminous-shale, tin-stone crystals, black cobalt ore.

3. *Dark-black.* This is the proper black colour, or perfect black, being unmixed with any other colour. It occurs in obsidian, otherwise called Iceland agate, shorl, jet.

4. *Iron-black* is a perfectly dark and metallic black colour, occurring sometimes lighter, sometimes darker. In the latter case, being dark-black, it is found in micaceous iron ore from Tobschau in Upper Hungary. In the former, in which it shows a slight admixture of grey or white, and then also passes into steel-grey, it occurs in magnetic iron-stone, sometimes in antimoniated silver ore, and frequently in micaceous iron ore.

5. *Bluish-black* is a black colour verging a little on blue, and constitutes the transition from the one colour into the other. It is present in aluminous shale, black cobalt ore, dull black-lead ore.

Sect. 50.—*Blue* is the fourth principal colour, and also one of the darkest. Several writers have considered it as a compound of black and white; how far this may be just, and whether it should not rather be deemed a simple colour, I shall not here inquire. In the refraction of the solar ray by the prism the blue colours appear uppermost.

The opinion expressed in the commencement of this paragraph is erroneous: indeed, the knowledge of the properties of light, which had just dawned in the mind of Newton, was only followed up, late in the last century, by Dr. Wollaston, Malus, Arago, and Dr. Brewster. Blue was proved to be a prismatic colour, both by Newton and Wollaston: the latter, in a more accurate experiment than any preceding philosopher had made, reduced the seven prismatic colours to four; blue being still found in the smaller number. Black is not a prismatic colour; and whilst the union of prismatic colours in the proportions in which they appear in the spectrum produces the idea of whiteness, the interference of rays of light produces darkness. "That two lights should in any circumstances produce darkness may be considered strange, but it is *literally true*: and it had been noticed long ago by Grimaldi, in his experiments on the inflection of light. The experimental means by

which Dr. Young confirmed this principle, which is known in optics by the name of the *interference* of the rays of light, were as simple and satisfactory as the principle itself is beautiful,—the verifications of it still more so." The reader will find the explanation of this theory in Herschel's preliminary discourse, sect. 286, *et seq.* These statements will disprove our author's supposition: first, by proving blue to be a prismatic colour; and then by showing that blue, in union with other colours, produces both black and white, and, therefore, it cannot be a union of black and white which produces blue.—*Wern. Club.*

Blue is the rarest colour in the mineral kingdom, so that we can scarcely exhibit more than eight or ten species to which it is peculiar. It cannot be said to appertain particularly to one or the other genus. Formerly, it was exclusively appropriated to copper; this, however, has been sufficiently contradicted by the discovery of blue in iron, and in several earths and salts. The following varieties occur in minerals:—

1. *Indigo-blue.* This, which is the darkest of the blue colours, inclining a little to black, constitutes the transition from one into the other. Its name is derived from the indigo employed in painting to produce this colour. Ex. Blue martial earth, from Eckartsberg, near Weissenfels, in Saxony.

2. *Prussian-blue.* This is next darkest in shade, and, not inclining to any other colour, may properly be called perfect, or pure blue. The denomination is derived from prussian-blue, used in painting, with which it coincides. I have never met with the proper, or dark prussian-blue, in the mineral kingdom; but of the light prussian-blue we have sapphire and blue rock-salt.

3. *Azure-blue* is a clear blue, inclining a little to red. The name of this colour is borrowed from lapis lazuli, from which the valuable pigment called "ultramarine" is prepared, and with which it coincides. It is present in lapis lazuli and dark azure copper ore.

4. *Violet-blue, or violet,* is a rather clear reddish-blue colour, and appears to consist of a mixture of azure-blue and crimson-red, into which two colours it also forms the transition. It is the uppermost colour among those produced by th refraction of the solar ray in the experiment with the

prism. We meet with it in violet blossoms, whence the denomination is derived. It occurs in amethyst of every degree of shade, fluor spar, lithomarge (the well-known "terra miraculosa Saxoniæ"), spinell ruby, and more rarely in calcareous spar, and apatite; also in rock salt.

5. *Smalt-blue.* This is a rather light-blue colour, and appears to consist of azure blue mixed with a little white. In the experiment with the prism it stands between violet and sky-blue. Its name is borrowed from the well-known smalt, from which this colour is produced for painting: light azure copper ore, light blue martial earth from Niederleschen, near Sprottau, in Silesia.

6. *Sky-blue* is a light blue colour, which inclines some little to green, and constitutes the transition from blue into green, viz. into verdigris-green. (Painters call this colour mountain-blue.) The denomination is derived from the colour of a clear sky. In the experiment with the prism, which has been so frequently mentioned, this colour is also produced, and appears between smalt-blue and grass-green, into which last it gradually passes. It is found in light azure copper ore, blue natural vitriol, and sky-blue fluor.

Sect. 51.—We now come to *Green*, the fifth principal colour. It is a clear mixed colour, composed of blue and yellow, and forming the transition from one into the other. In the refraction of the solar ray by the prism, there is a green which is medium between grass-green and canary-green. It there appears between sky-blue and lemon-yellow.

Green is not very common in the mineral kingdom, though it occurs much more frequently than blue. It appears to belong in particular to copper; lead, however, and several other metals, and many earths and stones, also lay claim to it. Its varieties occurring in fossils are the following:—

1. *Verdigris-green*, which is a clear bluish-green colour, in whose mixture yellow is not perceptible. It forms the transition from green into blue. It coincides in colour with common verdigris, and hence the denomination has arisen. It is present in green copper ore, verdigris-green fluor.

2. *Mountain-green* is a light and almost greyish-green colour. Here a tint of yellow may already be perceived in the mixture of the colour; blue, however, still predominates. Its name is borrowed from a pigment with which it nearly agrees. It passes into greenish-grey, and thus constitutes the transition from green into grey. It occurs in green hornstone from Altenberg, Saxon aquamarine, most berylls, actynolite.

3. *Emerald-green* is a clear pure green. It seems to consist of equal parts of prussian-blue and lemon-yellow. The denomination is derived from the emerald, in which this colour is particularly distinct; it is also found in fibrous malachite and fluor spar.

4. *Grass-green* is a clear pure green, in which yellow however, already predominates. The denomination of this colour is derived from the fresh grass of spring. In the mineral kingdom we find it in chrysoprase and some green lead ores.

5. *Olive-green* is a light green colour, verging considerably on brown. It is found in most green lead ores, many serpentines; among others, that of Saalburg in Sweden; actynolite, from Burg d'Oiseau in Dauphiné; chrysoprase, many pitchstones, garnets, calcareous spars, and other minerals.

6. *Blackish-green* is a very dark leek-green, mixed with much black. It occurs almost exclusively in the dark-green serpentines.

Sect. 52.—*Yellow*, being the sixth, is a very light principal colour. Of its varieties, two are produced in the refraction of the solar ray by the prism, appearing between green and red.

Yellow is very prevalent in the mineral kingdom, but not peculiar to any particular genus. The varieties which occur, according to the different admixtures of other colours, are the following:—

1. *Sulphur-yellow* is a light greenish-yellow colour. It forms the transition from yellow into green. The denomination is borrowed from sulphur, in which this colour

particularly occurs. We find it in natural sulphur, and sulphur-yellow serpentine from Zöblitz in Saxony.

2. *Lemon-yellow* is a clear pure yellow. To produce this colour painters make use of gum guttæ. It is also commonly called gold-yellow ; but this belongs more particularly to the next succeeding colour. In the refraction of the solar ray by the prism, which has been so frequently mentioned, it appears between green and orange-yellow. We meet with it in orpiment, and some yellow lead ores.

3. *Gold-yellow*. This is a metallic clear yellow, in which no admixture of another colour is perceptible. Excepting the metallic lustre, it agrees perfectly with the preceding colour. Borrowed from gold ; to which this colour is peculiar. It is found in native gold.

4. *Bell-metal-yellow*. This is a metallic pale yellow, inclining very little to reddish ; it seems to consist of pale gold-yellow, very little brownish-red, and grey. Derived from bell-metal, with the colour of which it agrees. We have bell-metal-yellow martial pyrites.

5. *Straw-yellow*. This is a pale yellow, composed of sulphur-yellow and a little reddish-grey. It is particularly found in straw, whence the denomination is taken. It occurs in yellow jasper from Lessa, near Carlsbad, in Bohemia ; calamine, and bismuth-ochre.

6. *Wine-yellow* is a pale reddish-yellow, appearing to consist of pale lemon-yellow, and some little brownish-red. We find this colour in yellow, or white wines, whence the denomination is borrowed. Among minerals, it is present in topaz from Schneckenstein, near Auerbach, in Saxony, yellow cuneiform calcareous spar from Poland.

7. *Ochre-yellow* is a rather dark yellow, consisting of lemon-yellow and a little brown. It is found in yellow iron ochre, from which its name is derived, most yellow jaspers, calamine.

8. *Orange-yellow*. This is a dark reddish-yellow, seeming to consist of lemon-yellow and red. It forms the transition from yellow into red, viz. into aurora-red. In the

experiment with the prism it appears between lemon-yellow and red. We have orange-yellow amber, orange-yellow cornelian, orange-yellow calamine; of this colour is also the streak of realgar, and red-lead ore.

9. *Brass-yellow:* a light metallic colour, composed of gold-yellow and a little green. It verges sometimes more, sometimes less, on green. It is peculiar to copper pyrites, particularly on the fresh fracture, and brass-yellow native gold, which is argentiferous.

Sect. 53.—*Red* is a simple and rather clear principal colour, and the seventh in the series. In the experiment with the prism, it is the lowest among the colours.

It is one of the most common colours in the mineral kingdom, and seems to be particularly appropriate to iron. We have the following varieties:—

1. *Morning*, or *aurora-red*, is a clear yellowish-red, composed of scarlet-red and orange-yellow. (*See* Schœffers' "Sketch of a general Display of Colours," Tab. II. Num. 1.) It constitutes the transition from red into yellow. In painting it is produced by minium. Derived from the colour of the morning dawn, with which it agrees. Of this colour we have red-lead ore from Siberia; realgar, and in some spots yellow blende, from Scharfenberg.

2. *Hyacinth-red* is a clear red much resembling the former, and differing only in a slight admixture of brown. In red-lead ore, a variety of brown blende, hyacinth.

3. *Brick-red* is a light red, composed of aurora-red, a little white, and very little brown. It occurs in newly-burnt bricks, whence the name is taken. In the mineral kingdom we find it distinct in a variety of porcellanite, from Strakke, in Bohemia; occasionally also in jasper and pitchstone.

4. *Scarlet-red* is a clear red, inclining a little to yellow, and seems to consist of crimson-red and a little lemon-yellow. (*See* Schœffers' "Sketch of a general Display of Colours," Tab. II. Number 3.) To produce this colour painters make use of cinnabar. It is the same red as that

obtained in the refraction of the solar ray by the prism. It is found in light red cinnabar from Muschellandsberg in the Palatinate.

5. *Copper-red* is a metallic light yellowish-red. Derived from copper, with the colour of which it agrees. It is present in native copper, and sulphurated nickel; this latter, however, inclines a little to silver-white.

6. *Blood-red* is a dark red, appearing to consist of crimson-red and scarlet-red. Its denomination is taken from blood, to which this colour is peculiar. It occurs in Bohemian garnet, red cornelian, and quartz from Compostella and Valencia in Spain.

7. *Carmine-red* is a clear red, in which an admixture of another colour is not perceptible, and may therefore be considered as the proper or pure red. (*See* Schœffers' "Display," &c. Tab. II. Num. 4.) Derived from the carmine-red of painters. Among minerals we meet with it in capilliform red copper ore, clear red cinnabar from Hartenstein near Schneeberg, and from Rosenau in Hungary.

8. *Crimson-red* is a clear bluish-red, which seems to consist of carmine-red and some prussian-blue. (*See* Schœffers' "Display," &c. Tab. II. Num. 2.) It constitutes the transition from red into blue, viz. violet-blue. Of this colour we have ruby, Oriental garnet, striated red cobalt ore.

9. *Flesh-red.* This is a pale red colour, composed of crimson-red and yellowish-white. (*See* Schœffers, &c. Tab. II. Num. 110.) It agrees with the colour of the human flesh, whence the denomination is derived. It occurs in flesh-red baroselenite, flesh-red felspar, red gypsum, red quartz, red lithomarge.

10. *Brownish-red* is a rather dark red, composed of blood-red and some brown, and forms the transition from red into brown. (*See* Tab. II. Num. 8. of Schœffers' "Sketch," &c.) We meet with it in red argillaceous ironstone from Wehrau in Upper Lusatia, red jasper-like ironstone, red ironstone of loose earthy consistence.

Sect. 54.—The eighth and last principal colour is *Brown*, being a mixture of a little yellowish-red and black, and

forming the transition from one into the other. It is the darkest colour next to black. It is frequent in occurrence among minerals, and in particular among iron ores and inflammable substances. In the mineral kingdom we have the following varieties of brown :—

1. *Reddish-brown* is a clear and almost dark brown, verging closely on blood-red. It is present in brown tinstone and brown blende, rarely however.

2. *Clove-brown* is a dark brown, verging almost imperceptibly on carmine-red. Derived from cloves, with the colour of which it agrees. It occurs in compact brown ironstone, brown sparry iron ore, brown rock crystal from Zinnwald in Saxony, rarely in amethyst, but in most thumerstones from Dauphiné.

3. *Hair-brown* appears to be a medium between yellowish-brown and clove-brown, with a slight admixture of grey. Of this colour we have wood-tin ore from Cornwall.

4. *Yellowish-brown* is a light brown, verging on ochre-yellow. It constitutes the transition from brown into yellow. We find it in brown iron ochre, swampy iron ore from Sprottau in Silesia, jasper.

5. *Tombac-brown.* This is a metallic light yellowish-brown, which seems to consist of gold-yellow and reddish-brown. It much resembles tarnished tombac, from which the name is taken. It is found in brown mica.

6. *Wood-brown* is very pale, being a mixture of yellowish-brown and much ashes-grey. Distinct in half-decayed wood, bituminous wood, and a variety of asbestus.

7. *Liver-brown* is a light brown, consisting of blackish-brown inclining a very little to green. It is the colour of liver, whence the name is borrowed. Among minerals we meet with it in brown cobalt ore, brown jasper from Auerswalde, near Chemnitz, in Saxony.

8. *Blackish-brown* is a dark brown verging on black, and constitutes the transition from brown into black. Blackish-brown lowland argillaceous iron ore from Oelsse, near Saagan, in Silesia, mineral pitch, bituminous wood, onyx.

SECT. 55.—By the several varieties the colours of minerals may be determined; but, although I have collected a considerable number, I will not deny that several others may be discovered by future experience. Should this take place, it will no longer be difficult to give to any new colour a systematic denomination, to determine its character, and to locate it in the system.

SECT. 56.—Several minerals cannot be said to possess any certain colour, being either a mean between two colours (as, *e.g.* compact malachite, the colour of which is a mean between verdigris-green and grass-green; micaceous uranite; yellow earthy-lead ore, between sulphur-yellow and lemon-yellow; yellow cornelian, between lemon-yellow and wine-yellow; magnetic pyrites, between bell-metal-yellow and copper-red; red silver ore, which is generally a mean between crimson-red and lead-grey, &c.;) or inclining a little to a different colour (as, *e.g.* white copper ore, in which silver-white inclines a little to gold-yellow; red hæmatite, in which brownish-red inclines to steel-grey.) These are said to be of that colour to which they bear the nearest relation, and the extent of variation is afterwards determined, as, *e.g.* Oriental garnet, in which the crimson-red verges a little on black; vitreous silver ore, in which lead-grey colour verges on black.

II. THE SHADE OF COLOUR.

SECT. 57.—I have already mentioned, in sect. 46 of this chapter, that the shade of every variety of colour may be more clearly defined by saying, *e.g.* green hornstone is *clear* mountain-green, aquamarine is *pale* mountain-green, Bohemian garnet is *dark* blood-red, red cornelian is *light* blood-red.

III. THE TARNISHED COLOURS.

SECT. 58.—The *tarnished colours* are characteristic of several minerals: in using this term, we mean, that the colour of the surface differs from that of the fracture.

The tarnish proceeds from different causes; either from

an incrustation by another mineral, as variegated tarnished copper pyrites, yellow tarnished native silver, both of which are slightly incrusted with iron ochre; or from a change in the chemical constitution of the surface, and which may take place in a twofold manner, viz. either by its entering into combination with an extraneous substance (as black-tarnished native silver, which has become united to sulphur), or by losing one or more of its constituent parts (as black-tarnished native arsenic, variegated tarnished native bismuth); in both which cases the tarnish proceeds from a loss of the inflammable principle.[1]

Some minerals are only tarnished in their *natural position, i. e.* "in situ," as common galena, the drusen[2] of which are frequently found tarnished in fissures, as also blende, grey antimonial ore, specular iron ore. The fresh fracture of either of these does not tarnish.

Other minerals tarnish on *every fresh fracture* that is made, as native arsenic, grey cobalt ore, native bismuth, copper-pyrites.

Others, again, are always tarnished, both "in situ" and on *their fracture.* The most striking examples are, purple copper ore, native bismuth, native arsenic.

The tarnished colours themselves are *simple* or *variegated.* Of the former we have:—

1. *Grey*, which is the tarnished colour of white cobalt ore, and steel-grey of brown hæmatites.

2. *Black*, the tarnished colour of native arsenic (which is properly of a light lead-grey colour), brown hæmatites, and grey cobalt ore.

3. *Brown*, of native silver, which is properly silver-white.

[1] It may be observed here, and occasionally in the following pages, that at the time this was written the phlogistic theory of Stahl was in general acceptation.—*Trans.*

[2] The German term *drusen*, for which we have no corresponding English word, has been already adopted in the English language. It signifies an assemblage or group of crystals protruding from the same surface. See in the sequel, sect. 167, for the definition of *drusy*.—*Trans.*

4. *Reddish*, of native bismuth, if free from cobalt. Its fresh fracture is silver-white.

5. *Yellowish*, of white cobalt ore, argentiferous arsenical pyrites. Of the *variegated* we have,—

1. *Peacock tarnish* is an assemblage of yellow, green, blue, and red of nearly equal parts, with a dark shade of brown. Blue and yellow generally predominate, and yellow seems to be the ground colour; they are never precisely distinct, but always pass more or less one into the other. It principally occurs in copper pyrites, purple copper ore, common pyrites.

2. *Iridescent tarnish* consists of blue, green, yellow, and red, in nearly equal proportions, bearing some resemblance to the colours of the rainbow. Blue seems rather to predominate. It is chiefly present in grey minerals, *e.g.* the grey antimonial ore from Felsobania in Hungary; also in martial pyrites, galena, specular iron ore, arsenical pyrites, hepatic pyrites, and brown hæmatites.

3. *Columbine tarnish* consists of the lightest shades of white, red, green, very little yellow, and blue, and much grey (resembling in some measure the varied shades of the pigeon's neck). It occurs the most distinct in copper pyrites.

4. *Steel-coloured tarnish* consists of much grey, blue, red, yellow and green, representing the colours of hardened steel. This is also chiefly found in grey minerals, and occurs in grey cobalt ore.

IV. The Play of Colour.

Sect. 59.—The *play of colour* is only recognised in sunshine or other strong light. It is the property which some more or less transparent minerals possess of refracting in certain spots the incident rays of light, producing iridescent colours. This refraction of the solar rays originates in the peculiar association of the molecules of a mineral; frequently, however, it arises from accidental causes, such as slight rifts, cracks, &c. The diamond is the best example; sometimes also rock-crystal.

V. The Mutable Reflexion of Colour.

Sect. 60.—The *mutable reflexion of colour* is distinguished from the play of colour by the mineral displaying in the same spot a variable colour, accordingly as the angle of the incident rays of light is varied. This change takes place either *on the surface* of the fossil or *internally*, and is perceived by varying its position in relation to the eye, or by holding it up to the light. The *superficial* mutable reflexion of colour is particularly beautiful in Labrador felspar, and marble with variegated petrifaction of shells; the *internal*, in precious opal, moonstone, and cats-eye; though in the two latter it is rather a mutable reflexion of lustre than of colour. By holding semi-transparent common opal (whose colour is milk-white) to the light, it appears wax-yellow, and Oriental milk-white moonstone appears red, thus distinguishing it from that found in Switzerland.

VI. The Mutation of Colour.

Sect. 61.—*The mutation of colour* differs from the tarnish in this respect, that as in the latter the surface of the mineral alone undergoes a change of colour, so in the former the change penetrates into the interior, and sometimes even pervades the whole. Of this we have two modifications :—

1. *The fading of colour;* by which is meant, that the colour becomes paler by light, heat, decay, and other external causes. Thus striated red cobalt ore by exposure to the air becomes pale-brownish; blue fluor spar, green; chrysoprase, light green; pearl-grey horn silver ore, clear brown.

2. *The perfect change of colour.* This not unfrequently arises from fading, and is the loss of one colour and the production of another. Such a change is frequent in siderocalcite, light-coloured sparry iron ore, earthy grey ore of manganese, argillaceous ironstone.

The three subjects treated of in sects. 59, 60, 61, are involved in some degree of confusion, both in our author and in the works of subsequent writers. Thus Werner instances Labrador felspar to illustrate "mutable

reflexion of colour," whilst Chapman quotes it under the head of "play of colour."

We should rather combine these characters, viz. play of colour, mutable reflexion of colour, and mutation of colour, as well as iridescence and opalescence, under the modern term *Dicröism.—Wern. Club.*

VII. The Delineation or Disposition of Colours.

Sect. 62.—The *delineations of colours* proceed from a mixture of different varieties of one species, and take place when a homogeneous mineral contains in one and the same specimen several colours passing through its interior, in certain delineations. The following are the most common :—

1. *Dotted*—Fine points of another colour. We have dotted serpentine and jasper. Heliotrope and agate are not dotted, as their points arise from interspersed jasper.

2. *Spotted*—The spots are round and regular, or irregular.

3. *Nebulous*—Large and irregular spots, forming with the ground colour mixed colours, resembling clouds. It occurs in jasper, calcedony, lithomarge.

4. *Flamy*—or large spots vanishing in one direction.

5. *Striped*—when larpe spots, drawn in one direction, extend to, and run parallel through, the whole specimen. It is *straight* or *curved*, and *broad* or *linear*. Broad and straight-striped jasper, linear-striped agate, calcedony, &c.

6. *Annular*—or stripes forming concentric circles, as in jasper, cornelian, and flints. When the annular becomes angular it bears some resemblance to a fortification, which is not uncommonly found in agate and calcedony.

7. *Dendritic*—consists of a trunk-line delineation, separating into larger and smaller ramifications. Found in some limestones, bayreuth steatites, calcedony, &c. It differs widely from the dendritic delineation to be found on the surface of many minerals.

8. *Ruinous*—a delineation in which a resemblance to ruins may be easily conceived. Some parallel uniformly-coloured stripes, over which others extend in an horizontal direction, form this appearance. Ex. Florence marble.

9. *Veiny*—or narrow variegated stripes, crossing each other more or less in straight-lined and different directions, sometimes forming a kind of net. It occurs frequently in serpentine and marble.

The distinctions of colour may be thus briefly stated:—

i. The nature of the colour { Metallic. / Non-metallic.

ii. The disposition of the colour.

iii. Dicröism { Iridescence. / Opalescence. / Tarnish. / Play of colour.

Wern. Club.

The Cohesion of the Particles.

SECT. 63.—The *cohesion of the particles* is the *second common generic character* observable *by the sight*, as well as partly and peculiarly by the touch. By the sight, inasmuch as we perceive it in their external appearances; by the touch, when we examine them with our hand, as the common organ of feeling.

SECT. 64.—In minerals, as in all other substances, we call cohesion that attractive power by which their integrant particles cohere together, and by which they resist, more or less, the force applied to separate them.

SECT. 65.—If the molecules be both coherent and immoveable, or moveable with difficulty, one among another, as in flint, vitreous silver ore, chalk, &c., it is said to be *solid*. If coherent, and likewise easily moveable one among another, as in native mercury, it is said to be *fluid*.

SECT. 66.—Solid minerals are distinguished into *solid* in a restrictive sense, and *friable*. A mineral is solid if its individual particles constitute a single aggregation. Friable, if it consist entirely of small aggregations, and so small that not one can be individually examined (for otherwise it would be solid), but may be considered in a manner as molecules of the mineral which either do not cohere at all, or cohere very slightly.

SECT. 67.—I should now describe in what manner *solidity*,

friability, and *fluidity*, are examined and determined; but, as these three properties are *particular generic characters*, of which the first pertains to solid, the second to friable, and the third to fluid minerals, I refer them to their proper places, in which I shall separately treat of the *particular generic characters* of each, in the order in which they strike the senses.

I. Particular Generic Characters.

Of Solid Minerals.

Sect. 68.—*Solid minerals* are distinguished by many more external characters than friable, or fluid; they possess several properties which do not belong to the two latter: as in friable, the *external surface, transparency*, &c.; in the fluid, the *fracture, streak*, &c. This is of the greater advantage, as there are a far greater number of species and varieties of solid than of friable or fluid minerals.

Sect. 69.—We shall commence with those *particular generic characters* of solid minerals which are observed by the sight; then will follow those which are observed by the touch; and, lastly, those which are observed by the hearing. Among those observed by the sight, we first perceive the *external form*, then the *external surface*, the *external lustre*, the *internal lustre*, the *fracture*, the *form of the fragments*, the *form of the distinct concretions*, the *surface* of *separation*, the *lustre* of *separation*, the *transparency*, the *streak*, and, lastly, the *stain*.

Sect. 70.—The particular generic characters observable by the eye in solid minerals are of three kinds; for some, as the external form, the external surface, and the external lustre, are observed in the exterior only, and hence these three are collectively termed the *external appearance*. Others, again, as the internal lustre, the fracture, the form of the fragments (which constitute the *appearance* of the *fracture*), the form of the distinct concretions, the surface of separation, the lustre of separation (which constitute the *appearance* of

the *distinct concretions*), can be observed in the interior only, and hence are collectively termed the *internal appearance*. And others, as the transparency, the streak, and the stain, may be observed both in the exterior and interior, and hence are termed the *general appearance*.

SECT. 71.—The complete surface which a solid mineral has received from nature is called its *exterior;* thus the natural surface of a specimen of galena which has been found detached, or inhering in another mineral, is called its exterior; and hence all the characters which can be observed by the sight in this surface only are called the *external appearance* of minerals.

But as specimens occur which no longer possess their natural surface or exterior, as, *e.g.* if the forementioned specimen of galena were broken, so that no part of its natural surface should be retained, it follows that those external characters which belong to the external appearance cannot be observed in every specimen.

To the external appearance appertain, as already observed in the foregoing section, the external form, the external surface, and the external lustre.

THE EXTERNAL APPEARANCE.

1. *The External Form.*

SECT. 72.—The *external form* of a solid mineral is nothing more than the figure which its constituents are found to possess.

Solid minerals have either received this external figure in their formation, or acquired it gradually from other natural circumstances; as pebbles, which are the rounded fragments of other stones.

Now, those whose external figure originated in their formation, either had space sufficient to form themselves in a manner suitable to their nature, or the space which remained unoccupied by other minerals, and of which they possessed themselves in their production, was the cause of their ex-

ternal figure; or they formed themselves in and with others which were produced at the same time. The difference of the external figure of those which possessed ample space for their formation (and to which all crystallisations, several kinds of particular forms, as *dentiform*, *dendritic*, *stalactitiform*, and, lastly, of common forms, some kinds of *massive* belong) arises, 1st, from the different constitution of their integrant particles, in proportion as during their production they differently attracted and united with each other in their solution, and acquired different gravities (which have a material influence); 2dly, from the different solvents, and the kind of solution in which the minerals occurred in proportion as it was more or less intimate, and the different precipitants, which all contributed to produce a diversity of form; 3dly, from the attraction of the walls, or sides of the cavity, cleft, or fissure, in which it originated, which also produced an effect, inasmuch as it acted upon the dissolved particles at the time they were disposed to coalesce or associate together. The different external figure of those which formed themselves according to the space which they occupied (and to which among particular forms the *cellular*, among common forms the *interspersed*, and often also the *massive*, belong), proceeds so far from the minerals themselves as it was their nature to be produced in this or that mineral; but, in other respects, the cause is to be attributed entirely to the form of the space which they occupied. Lastly, the different external figure of those which were formed at the same time with the minerals in and with which they occur (and to which among particular forms the *veiny-cellular*, and among common forms the *interspersed*, frequently belong), proceeds partly from themselves, and partly from the minerals in and with which they originated.

SECT. 73.—The *external form* of solid minerals, as already observed in Sect. 71, is not present in every individual. Nor must we in all cases, from a difference of external form, immediately infer an essential difference; it may have arisen, as already shown in the foregoing section, from other circumstances as well as from the constitution, in

which case a variety is only produced. But as minerals of the same external form are very rarely met with, this character, particularly the crystallisation, assists us much in distinguishing them; and, indeed, in company with the two following, which constitute the external appearance, it must often serve us instead of the internal appearance, which cannot always be observed; as in the case of crystals which possess their perfect crystallisation. The external forms of solid minerals are distinguished into *common forms*, *particular forms*, *regular forms* or *crystallisations*, and *extraneous forms*.

1. *Common Forms.*

SECT. 74.—If the natural surface neither consists of a determinate number of sides, nor furnishes a resemblance to any known substances in common life, the mineral is said to be of a *common form*, *i.e.* of a form in which most minerals occur. It is then also said to be *without any particular form*, of *indeterminate form*, *amorphous*, and (very improperly) *heteromorphous*. There are six kinds of common forms, as *massive*, *interspersed* or *disseminated*, *in angular pieces*, *in grains*, *in plates*, and *superficial*.

SECT. 75.—A solid mineral which occurs of an indeterminate form or amorphous, and of nearly equal dimensions, from the size of an hazel-nut to the greatest magnitude, imbedded in and incorporated with another solid mineral, is said to be *massive*. Solid minerals are most usually found of this external form; several, indeed, are rarely found otherwise, as pit-coal, steatites, &c. We have massive native silver, massive galena, massive copper pyrites, quartz, limestone, rock-salt, and many others.

SECT. 76.—A solid mineral which occurs without any particular form, in little pieces not exceeding the size of a small hazel-nut and of nearly equal dimensions, here and there incorporated with another solid mineral, is said to be *interspersed*, or *disseminated*. Hence the difference in size constitutes the whole distinction between this and the preceding common form. Disseminated minerals are distin-

guished into,—*coarsely interspersed*, where the interspersed parts vary from the size of an hazel-nut to that of a pea; *finely interspersed*, from the size of a pea to that of a grain of millet; *minutely interspersed*, from the size of a grain of millet to one that is still perceptible to the eye. We meet with interspersed native gold, interspersed native silver, also cinnabar, martial pyrites, quartz, and many others.

SECT. 77.—The meaning of a mineral *in angular pieces* is, in a great measure, explained by the denomination itself. We have here, however, to observe, that the pieces must be large, namely, from the size of an hazel-nut to the greatest magnitude, and loose or detached, *i.e.* not imbedded in another mineral. Scarcely any other difference, therefore, exists between this character and massive, than that in the latter the mineral is inhering in another; in the former, on the contrary, it is detached. Minerals occurring in angular pieces may be further distinguished into *sharp-cornered* and *blunt-cornered.* Of this form are found calcedony, opal from Eibenstock in Saxony, yellow cornelian, flint, Bolognian stone.

SECT. 78.—A solid mineral which occurs amorphous, and loose or detached, in small pieces of variable size, is said to be *in grains*. This kind of external form differs from the preceding merely in point of size, and it differs from interspersed in this respect, that as the latter occurs in the matrix and incorporated with another mineral, so the former is found detached, or only loosely coherent. It is necessary to guard against confounding this kind of common form with what is called the *grain* and *granular*, of both which notice will be taken in the explanation and definition of the fracture. Grains may be further distinguished:—

1. With respect to the *size:* into *larger grains*, from the size of an hazel-nut to that of a pea; lowland argillaceous iron ore, pisiform argillaceous ironstone, are found in gross grains: *large grains*, from the size of a pea to that of hemp-seed; precious garnet, magnetic iron sand: *small grains*, from the size of hemp-seed to that of millet; the same minerals: *minute grains*, under which denomination all come

which are smaller than millet-seeds; platina, native gold, tinstone.

2. With regard to the *figure:* into *angular grains*, magnetic iron sand; *arundated grains,* Bohemian garnet and pisiform argillaceous ironstone; *flattened grains*, native gold, platina.

3. Accordingly as they *inhere* in other minerals, into *loose*, *partly*, and *wholly* inhering.

SECT. 79.—A solid mineral which occurs in flattened pieces inhering in, or adhering to, another solid mineral, and whose thickness varies from one inch to such a one as the fracture of the mineral will still admit of distinguishing, is said to be *in plates.* The essential difference between this and the preceding kinds is, that as in the latter all the three dimensions are nearly equal, so, on the contrary, in the former the thickness is less in comparison with the other. Plates rarely occur regular, being scarcely ever uniform in every part. Accordingly, we speak of *thick* and *thin* plates. Native silver and vitreous silver ore are examples.

SECT. 80.—When a solid mineral, without any particular form, occurs very thinly laid on the surface of another, it is said to be *superficial.* This kind is somewhat rare, and peculiar to certain metals only. Superficial is further distinguished into *thick, thin,* and *very thin* superficial. We have superficial native silver, red silver ore, vitreous silver ore.

2. *Particular Forms.*

SECT. 81.—*Particular external forms* are such as present a greater or less resemblance to substances and their parts, both natural and artificial. They are called *particular,* being not usual or common among minerals, like the preceding; and peculiarly appertaining to other substances. We have the following kinds of particular external forms:—

1st. those which are *elongated;* as,

dentiform,	*retiform,*
filiform,	*dendritic,* or *arboriform,*
capilliform,	*stalactitiform,*

coralliform, *fistuliform*,
tubuliform, *frutescent*, or *arbustiform*,
and *matraciform*.

2dly. *Rounded particular forms*; as,
botriform, *kidney-form*, or *reniform*,
globular, *bulbous*, or *nodular*,
and *liquiform*.

3dly. *Flattened particular forms*; as,
specular, *in laminæ*,
and *pectinated*.

4th. *Impressed particular forms*; as,
cellular, *corroded*,
with impressions, *heteromorphous*,
perforated, and *vesicular*.

5th. And lastly, a confused particular form, as,—*Ramose*.

Sect. 82.—*Elongated particular forms.*—*Dentiform* is that particular form of a solid mineral which adheres by the thicker end, and is elongated toward the other with a curve, terminated by a point. The denomination is derived from its resemblance to teeth. This kind of external form is found from the length of a quarter of an inch, and still less, to almost that of a foot. It is rare among metals. Ex. Dentiform native silver, dentiform vitreous silver ore, dog-tooth carbonate of lime.

Sect. 83.—A solid mineral is said to be *filiform* when it occurs in long slender columns resembling wire. It is also rare, and peculiar to some metals. When filiform becomes thick at one end and pointed at the other, it passes into dentiform. Ex. Filiform native silver from Norway, filiform vitreous silver ore.

Sect. 84.—A solid mineral in very thin threads is said to be *capilliform* (resembling hairs). It passes into filiform when the threads acquire a considerable thickness. Ex. Capilliform native gold, native silver, martial pyrites.

Sect. 85.—A solid mineral in slight columns or threads, part of which run parallel to each other, and are intersected at right angles by others also parallel to each other, is called *retiform* (net-shaped). Ex. Retiform native silver, retiform

native copper from Saska in the Banat,[1] retiform cobalt, and sulphurated nickel from the Himmelsfürst, near Freiberg; and even a kind of retiform galena.

Sect. 86.—A solid mineral which separates from one thicker stem into several (as it were) slender branches, which last also are frequently furnished with smaller shoots, is said to be *dendritic*, or *arboriform*. Dendritic is either regular, or irregular. The former nearly resembles fir-trees, the branches being at right angles with the stem, and the shoots at right angles with the branches. In the latter, the branches are connected with the stem under an acute angle. They are found in the slight fissures of solid minerals, and depend solely on their attraction and casual properties. Ex. Dendritic native silver from the Himmelsfürst, near Freiberg; irregular dendritic black hæmatites, Scheibenberg; and dendritic native copper.

Sect. 87.—*Coralliform* is applied to solid minerals which occur in elongated curved shoots, resembling coral, rounded at the extremities; but differ from stalactitiform, as the shoots in the former are variously curved, several arising out of each other, and often thicker at the end. Ex. Coralliform stalactite, native iron, brown hæmatites.

Sect. 88.—*Stalactitiform* applies to a solid mineral which consists of several straight shoots of a greater or less length, thickest at the part of adherence, slighter toward the extremity, and terminating convexly, or nearly conical. As the shoots are always formed in an open space by a succession of drops, and all possess one perpendicular direction when seen in the place of their formation, we may conclude that gravity was the sole cause of this figure. Stalactites and icicles are formed in one and the same manner. Ex. Stalactitiform brown ironstone, black hæmitites, stalactite, hepatic pyrites, calcedony.

Sect. 89.—*Tubuliform* consists in straight, nearly round, columns, mostly in one direction, contiguous, and adhering at both ends. Some years since galena was found in this

[1] Vid. Born Index fossilium, Pragæ, 8, 1772, p. 101, n. 7.

form in the Alten Morgenstern, near Freiberg, the columns invested with a brown fine-grained blende, often minutely crystallised; the interstices between the columns replete with the same substance. Ex. Compact brown ironstone, black ironstone, hepatic pyrites.

SECT. 90.—*Fistuliform* consists of either single or accumulated columns, round and internally hollow. Ex. Martial pyrites, stalactite.

SECT. 91.—*Frutescent*, or *arbustiform*, is applied to a mineral which separates into several thick and round branches, from one stem of the branches, terminating globularly, and rather closely crowded together. It occurs sometimes in compact black ironstone, rarely in stalactite, compact grey ore of manganese.

SECT. 92.—*Matraciform*. This rare form is composed of single contiguous columns adhering by the slighter end, and terminating in elongated globules. The term is derived from its resemblance to the matrass of chemists. Ex. Black hæmatites, brown hæmatites, compact grey ore of manganese.

SECT. 93.—*Rounded particular forms.*—*Botriform*. This form consists of globes arising out of each other, formed by the connexion of many greater or smaller globular sections. The term implies resemblance to a bunch of grapes. Black cobalt ore, grey ore of manganese, calcedony, malachite, copper pyrites, and striated martial pyrites, are found in this particular form.

SECT. 94.—A mineral which occurs in round pieces is said to be *globular;* of this there are several kinds: as,

Perfectly globular or *orbicular.*—Ex. Pisiform argillaceous ironstone, white cobalt ore.

Elliptical,—in elongated round pieces; quartz and flint pebbles.

Amygdaloid,—quartz, calcareous spar, zeolite, green earth.

Spheroidal,—Egyptian stone, cornelian.

Imperfectly globular approaches nearly to the form of a

globe, but has indeterminate and sometimes casual inequalities. Ex. Calcedony, agate, martial pyrites.

Sect. 95.—By *kidney-form*, or *reniform*, is understood that particular external form which consists of several larger or smaller globular elevations, each of which is composed either of one elevation, or of several smaller. It appears to owe its origin to a succession of drops, and hence passes into stalactitiform. The denomination is derived from its resemblance to the kidneys of the calf; and is further distinguished into *large* and *small* reniform. Ex. Red hæmatites, black hæmatites, martial pyrites, native arsenic, malachite, calcedony.

Sect. 96.—*Bulbous* or *nodular* implies irregular globular elevations, between which are similar depressions. Ex. Nodular flint, martial pyrites.

Sect. 97.—*Liquiform* is that particular form which consists of one or more flat round elevations, either detached or connected with each other; generally depressed in the middle; and occasionally accompanied by some minute globules. The term is derived from the resemblance to liquid metals, presenting a globular appearance with a small depression in the centre. Ex. Galena from the Alten grünen Zweig, Erbisdorf, near Freiberg.

Sect. 98.—*Flattened particular forms. Specular* is a solid mineral, which presents on one side an almost even polished surface. This surface, being smooth, generally possesses a considerable degree of lustre, and reflecting the rays of light is called specular, and in so far is a complex character. It is found in the walls of veins, and is merely a smooth separation of the vein from the rock. Ex. Compact galena, martial pyrites, compact red ironstone.

Sect. 99.—*In laminæ* is the term applied to a solid mineral, which consists of very thin plates, sometimes straight, sometimes curvated, inhering in another solid mineral, or merely adhering to it. This form is peculiar to some few metals. Ex. Native gold, native silver, vitreous silver ore.

Sect. 100.—*Pectinated.* This is formed by tables dis-

posed beside, and upon, each other; presenting the appearance of hair parted by the comb. Ex. Quartz from Schemnitz.

SECT. 101.—*Impressed particular forms.* A solid mineral is *cellular* when it consists of tables crossing and intersecting each other, thus forming cells. There are several kinds of cellular: as,

Hexahedral cellular; which may probably arise from a mineral insinuating itself into the rifts of others, which break in cubes or rhomboids, which, becoming decomposed, leave the hexahedral cells. Ex. Cellular martial pyrites.

Polyhedral cellular. This also consists of angular and straight-sided cells; in other respects indeterminate. Ex. Cellular quartz, cellular calcareous spar.

Parallel round cellular bears a close resemblance to honeycomb. Ex. Quartz and sparry iron ore.

Spongiform cellular, more irregular than the former; the lines not parallel, but confused. It occurs in quartz.

Indeterminate round cellular, in which almost every cell differs. Hepatic pyrites and brown ironstone are found in this particular form.

Double cellular; large cells, comprising several smaller; as in quartz and hepatic pyrites.

Veiny cellular, in which the cells are replete with other minerals; as in white cobalt ore, with interstices of manganese.

SECT. 102.—*With impressions.* This form may probably arise from the deposition of a soft mass upon a harder (particularly on crystallisations), becoming gradually indurated. We have,

Cubical impressions (commonly of fluorspar), which occur in quartz, martial pyrites, hepatic pyrites, hornstone, and calcedony.

Hexahedral pyramidal, in hornstone and quartz.

Conical, in native arsenic and quartz.

Prismatic and *tabular,* in quartz and some siderocalcites.

Globular, in vitreous silver ore.

These examples are commonly called "cap-crystals," from the matrix covering the crystal, and receiving the impression of its shape.—*Wern. Club.*

Sect. 103.—A solid mineral is said to be *perforated* when traversed with round, deep, and narrow holes. Ex. Argillaceous iron ore. This particular form may have originated from the minerals having been penetrated with roots, which decayed after the latter had become indurated.

Sect. 104.—A solid mineral is said to be *corroded* when entirely traversed with small cavities and interstices. The term is taken from worm-eaten wood, to which there is much resemblance. Ex. Vitreous silver ore, galena, quartz.

Sect. 105.—*Heteromorphous* is that particular external form which consists of larger or smaller indeterminate elevations and depressions, the former sometimes blunt, sometimes sharp. The denomination relates to the extraneous origin of the comparison. Ex. Native iron, argillaceous iron ore, swampy iron ore, native arsenic.

Sect. 106.—A solid mineral is said to be *vesicular* which possesses small cavities, more or less round, both on the exterior and interior. These cavities are not always connected one with another. Ex. Lavas, pumicestones, earthy scoria, some limestones, basalt, &c.

Sect. 107.—*Confused particular form. Ramose* is that particular external form which consists of several crooked branches, neither arising from a common stem, nor possessing a proportionate thickness; but irregular, growing one among another and out of each other, curved in different directions: they are sometimes thickest at the extremity, sometimes at the part by which they adhere; and they may have sharp sides and edges. When the branches become smaller, shorter, and thicker, this form passes into heteromorphous. Ex. Native iron from Siberia, sometimes also native copper, but very rarely vitreous silver ore.

3. *Regular Forms, or Crystallisations.*

Sect. 108.—The third kind of external forms, namely *regular forms* or *crystallisations*, are those surfaces which

consist of a determinate number of planes associated in a determinate manner.

SECT. 109.—Hitherto much neglect has been shown in the determination of crystals: the greater part having been very imperfectly defined by the number of their planes or solid angles, many having been indiscriminately called polyhedral (from the difficulty which was experienced in ascertaining their exact form); however, as crystals, by reason of their regularity, are not only capable of a more accurate definition than other external forms, but require a good definition on account of their variety, it is certainly necessary that a more careful attention should be bestowed on the subject.

Chapman defines crystallisations as follows: "Inorganic substances possessing a regular or symmetrical form, whether opaque or transparent."

Many systems have been based upon the crystal forms; but these are manifestly insufficient for any practical purpose, and have been adopted principally by those who have studied the subject as mathematicians. A glance at sections 116, 117, 118, 119, 120, 121, 122, will illustrate the heterogeneous substances which are associated together under such systems, and will prove the utter uselessness of them for all practical purposes. We shall endeavour elsewhere to give a comprehensive view of the modifications which the subject of crystallisation, considered scientifically, has undergone since the date of our author's work (*Vide* sect. 122).—*Wern. Club.*

SECT. 110.—In defining crystals we have four things to consider; their *essential quality*, *form*, *aggregation*, and *magnitude*.

1. *The essential quality of Crystals.*

SECT. 111.—By the *essential quality* of crystals is understood that distinction which refers to the mode of their formation; as having taken place, either in a manner conformable to the laws of nature, or unnaturally and irregularly. Accordingly crystals are distinguished into *genuine* and *spurious*. The former are by far the most frequent.

The latter appear to be produced in two ways: 1st, when genuine crystals, incrusted with a foreign substance, decay

in course of time, and leave the incrustation exhibiting their form; 2d, when genuine crystals which inhered in another substance, having decayed, the spaces so left became occupied by another mineral of later formation, which afterward, separating from the impressed mass, exhibits the form of the first (genuine) crystals. The former case is an incrustation of genuine crystals; the latter is a repletion of the space formerly occupied by genuine crystals. Both cases frequently occur in calcareous and fluor spars. Thus we have flint as the spurious, or after-crystal of the double trihedral pyramid of calcareous spar; calamine from Derbyshire, as the spurious crystal of the hexahedral prism of calcareous spar, acuminated by three planes; and quartz as the spurious crystals of the cube, and of the octahedron, of fluor spar.

Spurious crystals are particularly distinguished by the following characters:—

They are always *hollow*, or at least possess a small aperture; their surface is *rough*, or *drusy*, but never *smooth;* their solid angles, and edges, are never *sharp* or well-defined; they are not, like genuine crystals, connected by transitions with other crystals of the same constituent principles, but rather from their figure generally lead to the discovery of the mineral to which they casually owed their form.

2. *The form of Crystals.*

SECT. 112.—Form is an eminent property of crystals, since it commonly serves as a distinguishing character. Every crystal is composed of the following parts: *planes,* the definition of which may be found in geometry;[1] *edges,* formed by the junction of two planes under determinate angles, whose extremes therefore are lines; and *solid angles,* formed by the conjunction of three or more planes in one point.

[1] Euclid, Book I. Definition 7. "A plane surface is that which lies evenly between its extremities."

To determine the form of crystals it is first necessary to define their *primary* or *fundamental forms*, and then the several *variations* or *modifications* to which these are subject.

SECT. 113.—*Primary forms of crystals.* By the *primary forms* of crystals we understand their most simple forms (which consist of only one or at most of two kinds of planes, namely, lateral planes and extreme planes): and which, though they exist in crystals possessing a variety of planes, may yet be easily distinguished by conceiving those planes which lie nearest to the centre of the crystal, and which are generally the largest, to be extended on all sides until they conjoin.

The primary form is that into which a mineral may be cleaved by following the direction of certain natural joints. Our author simply describes *the forms* of crystals in this portion of the work, without attempting to point out the course pursued in nature in their formation. The theory of primary or primitive forms opens a wide question, which it is not our object to explore; the idea that they resemble the molecules of the crystals to which they belong is a theory at best—especially when we recollect that the crystals of some minerals may be reduced to two primary molecular forms, belonging to different systems of crystallisation. There must, therefore, after all, be something arbitrary in the selection.—*Wern. Club.*

SECT. 114.—*Parts of primary forms.* The parts, of which the primary forms of crystals are composed, are as follows:

Planes, or (apparently) level surfaces, bounded by right lines.
Where two planes meet, an *edge* is formed.
Where three edges join, a *solid angle* (or corner) is formed.
The union of planes, edges, and angles, therefore, forms a *regular geometrical solid or crystal.*—*Wern. Club.*

Planes are distinguished into,—

1. *Lateral planes;* which, considered as parts of the surface of the body, are of the greatest extent, but form the confines of the body toward its smallest extent.

2. *Extreme planes* (terminal planes or bases); which are of the smallest extent, and form the confines of the body toward its greatest extent.

Edges, which also differ, being,—

1. *Lateral edges;* which are formed either by the junction of lateral planes with extreme planes, as in the table; or by the junction of lateral planes one with another, as in the prism and pyramid.

2. *Extreme edges;* which arise, either from the junction of extreme planes one with another, as in the table; or from the junction of lateral planes with extreme planes, as in the prism and pyramid.

Solid angles, which have been already defined.

Sect. 115.—*Kinds of primary forms.* There are seven *kinds of primary forms*, and these are; the *icosahedron*, the *dodecahedron*, the *hexahedron*, the *prism*, the *pyramid*, the *table*, and the *lens*.—(*Vide* note at end of Sect. 122.)

Sect. 116.—The *icosahedron*, as the first, is that primary form which consists of twenty equilateral triangular planes, associated under equal angles. It occurs in martial pyrites and white cobalt ore; very rarely, however.

Sect. 117.—The *dodecahedron* is that primary form which is composed of twelve regular pentangular planes, associated under equal obtuse angles.[1] It must not be confounded with an hexahedral prismatic crystal, which occurs in calcareous spar, and which very much resembles it. The dodecahedron is found in martial pyrites, and also in white cobalt ore from Tunaberg in Sweden.

Sect. 118.—The *hexahedron* (in which are included the cube and the rhomboid), is that primary form which consists of six quadrilateral planes. This kind of crystal occurs very frequently in the mineral kingdom. Thus we have cubical crystallised cinnabar, cubical vitreous silver ore, corneous silver ore, galena, specular iron ore, martial pyrites, rock

[1] Abbé Haüy observes that the icosahedron and dodecahedron, described above by Mr. Werner as the regular solids of geometry, cannot exist in the mineral kingdom consistently with the laws of crystallisation. According to him, the icosahedron which occurs consists of eight equilateral and twelve isosceles triangles; and the dodecahedron varies in the angles under which its planes are associated.—Vide "Traité de Minéralogie," tom. i. pp. 80, 415, and 422; and tom. iv. pp. 70 and 79.—*Trans.*

salt, fluor spar, and rhomboidal crystallised calcareous spar, sparry iron ore, sidero-calcite, and many others.

Sect. 119.—The *prism* is that primary form which consists of an indeterminate number of quadrangular lateral planes, possessing one direction, and all terminating in two extreme planes, each of which has as many sides as the crystal possesses lateral planes. This is the most common crystal. We have prismatic green, white, black, and red-lead ores, tinstone crystals, arsenical pyrites, rock-crystal, quartz, topaz, shorl, and many others. Varieties: regular six-sided prism, right square prism, right rectangular prism, right rhombic prism, oblique rectangular and oblique rhombic prism, doubly oblique prism.

Sect. 120.—The *pyramid* is that primary form which consists of an indeterminate number of triangular lateral planes converging to a point, and of a base possessing as many sides as the crystallisation has lateral planes. Next to the prismatic this is the most frequent crystal. Ex. Light red silver ore, grey copper ore, quartz, calcareous spar, amethyst, prasium.

Sect. 121.—The *table* is that primary form which is composed of two parallel lateral planes, being very large in comparison with the other planes; and of an indeterminate number of little, narrow, and sometimes almost imperceptible, extreme planes, which are connected both with the lateral planes and with one another. Hence crystals of this kind are of a slight thickness, of a great length, and of a great breadth, always exceeding the thickness, but not so long. Tabular crystals are rather scarce. Ex. Specular iron ore, grey mica, calcareous spar, baroselenite.

Sect. 122.—The *lens* is that primary form which consists of two lateral planes only, differing accordingly as the lateral planes are differently curved. Hence there are two kinds: the *common* lens, composed of two convex lateral planes; and the *selliform*, consisting of one convex and one concave lateral plane, bearing some resemblance to a saddle, whence its name. Both common and selliform lenticular crystals occur in sparry iron ore, sidero-calcite, and calcareous

Tabular view of Systems of Crystallisation, with illustrative Examples:—

I. *The German "regular system."* Three axes, all equal length, and at right angles. Angl. *Octahedral or tessular system.*	Regular Tetrahedron. Hexadron or cube. Regular Octahedron. Rhomboidal Dodecahedron. Tetragonal Icositetrahedron.
II. *Two-and-one-axed system.* (Rose.) Three axes; two equal—all at right angles. *Pyramidal system.*	Right square Prism. Obtuse Pyramids } With square Acute Pyramids } common base. Combinations of square Prisms and Pyramids.
III. *Three-and-one-axed system.* Four axes; three equal, and crossing each other on the same plane at an angle of 60°; the fourth placed at right angles with the rest. Angl. *Rhombohedral.*	Obtuse Rhombohedrons. Acute Rhombohedrons. Regular six-sided Prism. Regular six-sided Pyramid. Combinations of the two latter.
IV. *One-and-one-axed system, or right unequiaxed system.* Three axes, all different, and at right angles. Angl. *Prismatic.*	Right rectangular Prisms. Right rhombic Prisms. Octahedrons with rectangular bases. Octahedrons with rhombic bases. Truncated varieties of the above forms.
V. *Two-and-one-membered system, or oblique unequiaxed system.* Three axes of unequal lengths; two of which cross each other obliquely, and one perpendicular to the third. Angl. *Oblique Prismatic.*	Oblique rectangular Prisms. Oblique rhombic Prisms. Pyramidal varieties of the above with oblique bases; and with oblique terminal planes, if imperfect.
VI. *One-and-one-membered system, or doubly oblique unequiaxed system.* Three axes of unequal length, all placed obliquely to each other. Angl. *Doubly oblique Prismatic system.*	Doubly oblique Prisms.

See Chapman's "Brief Description of the Characters of Minerals," p. 15, *et seq.*; and "Introductory Lecture on the Fundamental Relations of Mineralogy," &c. pp. 19–22.—*Wern. Club.*

SECT. 123.—*Differences in each kind of primary form.* These primary forms, whether perfect or variously modified, differ further from each other in respect to *simplicity*, *position*, the *number* and *size* of the *planes*, the *angles under which* these *are associated*, the *direction* of the *planes*, and the *fulness* of the crystals.

SECT. 124.—Primary forms are either *simple* or *double*. This distinction, however, is confined to the pyramid, as the other six kinds of primary forms occur simple only. In the double pyramid two cases occur with respect to the apposition of the lateral planes: in the one, the lateral planes of the one pyramid are set *directly* on the *lateral planes* of the other, which is the general case, or *obliquely*, as in double hexahedral pyramidal calcareous spar; in the other, the lateral planes of the one pyramid are set on the *lateral edges* of the other, as in double trihedral pyramidal calcareous spar. Ex. Simple pyramidal light-red silver ore, grey copper ore, quartz, amethyst, and double pyramidal vitreous silver ore, galena, tinstone crystals, rock-crystal, calcareous spar, ruby, diamond.

SECT. 125.—The difference in *position* is also peculiar to the simple pyramid; which, accordingly as it is found adhering to another mineral by the base or by the apex, is said to stand *erect* or *inverted.* The former case is the most common, the latter having occurred only in a few specimens of simple hexahedral pyramidal crystals of calcareous spar.

SECT. 126.—The *number* of *planes* in the primary form is in some kinds *determinate*, in others *variable*. It is determinate in the icosahedron, dodecahedron, hexahedron, and lens; of which the first cannot possess more than twenty planes, the second than twelve, the third than six, and the fourth than two. It is variable in the other kinds. In the prism and pyramid the lateral planes vary, and in the table the extreme planes vary. Thus the prism occurs:—

1. With *three* lateral planes in the trihedral prism of shorl, tourmaline, and cinnabar.

2. With *four* lateral planes in the tetrahedral prism of arsenical pyrites, jargon, and tinstone.

3. With *six* lateral planes in the hexahedral prism of green-lead ore, calcareous spar, and dark-red silver ore.

4. With *eight* lateral planes in the octahedral prism of topaz, vitreous silver ore, and dark-red silver ore.

The pyramid occurs,—

1. With *three* lateral planes in the simple trihedral pyramid of grey copper ore, and copper pyrites; and in the double trihedral pyramid of calcareous spar, and siderocalcite.

2. With *four* lateral planes in the double tetrahedral pyramid of ruby, galena, and vitreous silver ore.

3. With *six* lateral planes in the simple hexahedral pyramid of light-red silver ore and quartz, and in the double hexahedral pyramid of calcareous spar, and striated red cobalt ore.

4. With *eight* lateral planes in the double octahedral pyramid of garnet, zeolite, and native gold.

The table, though it possess only two large lateral planes, is yet variable in its number of extreme planes, which are always as many as the sides of the lateral planes.

The table occurs,—

1. With *four* extreme planes in the quadragonal table of baroselenite, yellow lead ore, and calamine.

2. With *six* extreme planes in the hexagonal table of mica, antimoniated silver ore, and baroselenite.

3. With *eight* extreme planes in the octagonal table of yellow lead ore, apatite, and baroselenite.

The prism and pyramid may possess a greater number of lateral planes, and the table, of extreme planes; but in the former the number of lateral planes never falls below three, and in the latter the number of extreme planes never below four;[1] and in the one or the other, the num-

[1] To this there seems to be an exception in the case of grey copper ore.—*Trans.*

ber of lateral planes or of extreme planes rarely exceeds twelve.[1]

On this subject I will only further remark that, without paying any particular attention to the equality of angles, the simple trihedral pyramid is called *tetrahedron*, and the double tetrahedral pyramid *octahedron*.

SECT. 127.—With regard to the *size* of the *planes* in relation to each other, there is rarely anything very determinate. The variation is chiefly observable in the lateral planes of the prism and pyramid, and in the extreme planes of the table. We have here to observe the *length* and the *breadth* of the planes. In relation to the breadth, the planes are *equal* or *unequal*, and in the latter case *indeterminate* or *determinate*. The lateral planes of the hexahedral prism of rock-crystal are in general indeterminately unequal. The lateral planes of prismatic white-lead ore from La Croix, and of hexahedral prismatic calcareous spar from Andreasberg, are determinately unequal, being *alternately broad* and *narrow*; so are the lateral planes of broad prismatic rock-crystal, and of prismatic gypsum in general, in both which *equal broad* or *narrow* planes are opposed to each other.

SECT. 128.—The *angles, under which the planes are associated*, are the following:—

1. The *angles* of the *lateral edges*, the idea of which is already conveyed in the definition of the lateral edges. In relation to these, the planes of crystals are said to be associated either *equiangularly*, *rectangularly*, *oblique-angularly*, or *unequiangularly*.

In the icosahedron the planes are always associated equiangularly, as may be seen in the icosahedral crystals of martial pyrites.

In the *regular* dodecahedron the planes are always equiangularly associated; in the *irregular*, on the contrary, the

[1] It is worthy of remark, that among the polyhedral crystallisations of the prism, pyramid, and table, not one of the two former has hitherto been found with five or seven lateral planes, or of the latter with five or seven extreme planes.—*Trans.*

planes are unequiangularly associated. Examples occur in martial pyrites.

In the hexahedron the planes are sometimes rectangularly, sometimes oblique-angularly, associated; the former case occurs in cubical fluor spar, calcareous spar, and vitreous silver ore; the latter in rhomboidal calcareous spar, siderocalcite, and felspar.

In the trihedral prism the lateral planes are generally equiangularly associated, as in the trihedral prism of shorl, tourmaline, and cinnabar. In the tetrahedral prism, on the contrary, the lateral planes are associated either rectangularly (Ex. Rectangular tetrahedral prism of garnet, and jargon), or oblique-angularly (Ex. Oblique angular tetrahedral prism of baroselenite, and arsenical pyrites). The lateral planes of the hexahedral prism occur partly equiangularly, and partly unequiangularly, associated: the former in the equiangular hexahedral prism of calcareous spar, emerald, and green-lead ore; the latter in the unequiangular hexahedral prism of rock-crystal, and baroselenite. The octahedral prism occurs rarely, and either with equiangularly or unequiangularly associated lateral planes; the former in the equiangular octahedral prism of dark-red silver ore, the latter in the unequiangular octahedral prism of topaz.

The trihedral pyramid occurs commonly with equiangularly associated lateral planes, as in the trihedral pyramid of grey copper ore, and diamond. The tetrahedral pyramid is found both with equiangularly and oblique-angularly associated lateral planes; the former in the double rectangular tetrahedral pyramids, or octahedra, of the diamond, magnetic ironstone, and red copper ore; the latter in the oblique-angular tetrahedral pyramid of natural sulphur. Lastly, hexahedral and octahedral pyramids are usually found with equiangularly associated lateral planes: the former in sapphire and rock-crystal; the latter in garnet, native gold, and martial pyrites.

One case only occurs in which the angles of the lateral edges of the table are unequal. Ex. Hexagonal table of

specular iron ore, in which the extreme planes are alternately obliquely applied to the lateral planes.

2. The *angles* of the *extreme edges*. In prisms the angles of the extreme edges are generally *rectangular*, the extreme planes being rectangularly applied to the lateral planes. Exceptions, in which the angles of the extreme edges are *oblique-angular*, occur in the tetrahedral prism of felspar and red-lead ore, with parallel obliquely-applied extreme planes. In pyramids the angles of the extreme edges are generally equal. In tables, on the other hand, the same case occurs with respect to the angles of the extreme edges, as in prisms with respect to the angles of the lateral edges. Thus we have quadragonal tables, in which the extreme planes are associated sometimes rectangularly, sometimes oblique-angularly (Ex. The rectangular quadragonal table of baroselenite and micaceous uranitic ore, the oblique-angular quadragonal table of baroselenite and prehnite); and hexagonal tables, in which the extreme planes are sometimes equiangularly, sometimes unequiangularly, associated; as in the equiangular hexagonal table of mica, and antimoniated silver ore, the unequiangular hexagonal table of prehnite.

3. The *angles* of the *summit* or *apex*, which are confined to the pyramid, are distinguished into—*very obtuse*, *obtuse*, *rather obtuse*, *rectangular*, *rather acute*, *acute*, and *very acute*. The extremes of obtuse-angular summits are found in the double trihedral pyramid of calcareous spar, in the very rare double trihedral pyramid of tourmaline, and in the double trihedral pyramid of the Brazilian diamond; the summit of the double hexahedral pyramid of calcareous spar is *acute angular*, and the summits of the double hexahedral pyramid of sapphire, and of the double tetrahedral pyramid of arsenical pyrites, are *very acute*.

Sect. 129.—The *direction* of the *planes* is either *straight* or *curvated*. Straight planes are even surfaces, and by far the most common. Curvated planes are much more rare, and are distinguished,—

1. In relation to the *position* of the curvature, into

inwardly curvated or concave, and *outwardly curvated* or convex.

2. In relation to the *form* of the curvature, as resembling a spherical, cylindrical, or conical section, into *spherical, cylindrical,* and *conical* planes.

Spherically-convex planes occur in cubical white cobalt ore, cubical fluor spar, and cubical martial pyrites; spherically-concave in cubical galena, cubical martial pyrites, and cubical fluor spar. Cylindrically-convex planes are found in the Brazilian diamond, trihedral prismatic shorl, and tourmaline; cylindrically-concave in hexahedral pyramidal calcareous spar, in rhomboidal siderocalcite, and in tetrahedral prismatic arsenical pyrites. Conically-convex planes occur in trihedral pyramidal brown and black blende; and conically-concave indistinctly in galena.

Sect. 130.—With respect to *fulness,* crystals are *perfect* or full, *hollow at the extremity,* or the *cavity* runs through the *whole crystal.* Genuine crystals are commonly found perfect or full, with some few exceptions which occur hollow. Thus we have crystals of calcareous spar, green-lead ore, cubical corneous silver ore, hexahedral prismatic dark-red silver ore, which are hollow at the extremity; and prismatic beryl, in which the cavity runs sometimes parallel to the direction of the lateral planes through the whole crystal.

Sect. 131.—*Modifications of the primary forms.* The *variations* or *modifications* of the primary forms, by which they sometimes lose their extreme planes, sometimes their peculiar edges, and solid angles, are caused by *truncation, bevelling,* and *acumination.* The planes which arise from these variations may be easily distinguished from the planes of the primary form, being more distant from the centre of the crystal, and in general smaller, than the latter.

Sect. 132.—*The truncation.* A crystal is said to be *truncated* when some or all its peculiar solid angles, or edges, appear cut off, in a manner; a plane occurring where a point or edge should be. Hence truncation consists of single planes only.

We have here to consider:

1. The *parts* of the truncation, as consisting of the plane, edges, and angles, of truncation.

2. The *determination* of the truncation, as relating to—

(*a*) The *situation;* which occurs either at the angles or edges of the primary form.

(*b*) The *magnitude;* which, in relation to the planes of the primary form, is small or large; in the former case the angles or edges of crystals are said to be *slightly,* in the latter *deeply, truncated.*

(*c*) The *application;* which is either *direct* (the most usual case), or *oblique, i.e.* set on one plane in particular. Instances of oblique truncation occur in the angles of the common base of the double trihedral pyramid of specular iron ore, and in the edges of cubical martial pyrites.

(*d*) The *direction;* the truncating plane being either an *even* surface (which is generally the case), or *curvated.*

Truncation is met with in cubical, prismatic, pyramidal, and tabular crystals; but chiefly in the three former. Among truncated crystals are cubical galena, with truncated angles; tetrahedral prismatic tinstone crystals, with truncated edges; double tetrahedral pyramidal tinstone crystals, with truncated edges; double tetrahedral pyramidal galena, with truncated angles; octagonal tabular baroselenite, with slightly truncated lateral edges.

SECT. 133.—*The Bevelling.* A crystal is said to be *bevelled* when some or all its edges, extreme planes, or solid angles, are so altered as to present in the altered part two smaller converging planes, terminating in an edge. This is the rarest kind of variation with which crystallisations are found.

We have here to observe:

1. The *parts* of the bevelling, as consisting of the *bevelling planes;* of the *bevelling edges* (distinguished into the *proper bevelling edge* formed by the conjunction of the bevelling planes; and the *bevelling edges* formed by the junction of the bevelling planes with the lateral planes of the primary form); and of the *bevelling angles.*

2. The *determination* of the bevelling, as relating to—

(*a*) The *situation;* which occurs either at the extreme planes, at the edges, or the solid angles, of the primary form. The bevelling of the extreme planes is confined to the prism and table; of the edges, it occurs in the hexahedron, prism, pyramid, and table; the bevelling of the solid angles is very rare.

(*b*) The *magnitude;* in relation to those of the primary form, which are small, or great: in the former case, the extreme planes, edges, or angles of crystals, are said to be *slightly*, in the latter *deeply, bevelled.*

(*c*) The *angle* under which the bevelling planes conjoin; either acute, rectangular, or obtuse: hence some crystals are said to be *acutely, rectangularly,* or *obtusely bevelled.*

(*d*) The *continuation* of the bevelling, as being *uninterrupted* or *interrupted,* and this *once* or *twice* interrupted. Ex. Acute-angular double trihedral pyramidal calcareous spar, with the lateral edges once interruptedly bevelled; and oblique-angular quadragonal tabular baroselenite, with the obtuse extreme edges twice interruptedly bevelled.

(*e*) The *application* of the *bevelling itself,* as being *direct* (the most usual case), or *oblique,* which occurs in hexahedral prismatic basaltic hornblende; and of the *bevelling planes,* as being set on the lateral plane, or on the lateral edges, of the primary form.

This kind of modification of the primary form is found in tetrahedral prismatic arsenical pyrites, with the extreme planes very obtusely bevelled; in rectangular quadragonal tabular baroselenite, with acutely-bevelled extreme planes; in cubical fluor spar, with bevelled edges; in trihedral prismatic tourmaline, with the lateral edges obtusely bevelled; in trihedral pyramidal grey copper ore, with bevelled edges; in oblique-angular quadragonal tabular baroselenite, with the obtuse extreme edges bevelled; in tetrahedral prismatic jargon and tinstone, with bevelled angles; in double tetrahedral pyramidal tungsten, with the angles of the common base slightly bevelled; and in double tetrahedral pyramidal martial pyrites, with all the angles bevelled.

SECT. 134.—*The acumination.* *Acumination* is that modification of the primary form whereby a crystal loses some or all its angles, or extreme planes, presenting in their stead, at the altered part, three or more planes converging together. This kind of variation is the most common which is found in crystals.

We have here to consider:

1. The parts of the acumination: viz. the *acuminating planes;* the *edges* of acumination (which are distinguished into the *proper* edges of acumination, formed by the junction of the acuminating planes with each other; the *extreme* edge of acumination, which sometimes occurs instead of a point; and the edges of acumination, formed by the junction of the acuminating planes with the lateral planes of the primary form); and the *angles* of acumination.

2. The *determination* of the acumination, as relating to—

(*a*) The *situation* of the acuminating planes, which occur either at the *solid angles,* or at the *extreme planes,* of the primary form. The acumination of the prism is always situated at the extreme planes, of the cube usually at the angles, and of the pyramid generally at the summit. Acuminations of the cube occur in cubical martial pyrites, whose angles are acuminated by three planes set on the lateral edges; and in cubical fluor spar, zeolite, and martial pyrites, with the angles acuminated by three planes set on the lateral planes. Acuminations of the pyramid at the angles occur in the double trihedral pyramid of the diamond, as already described; and in the trihedral pyramid of grey copper ore, with the angles acuminated by three planes.

(*b*) The *planes themselves;* in which we have to observe,—

1. Their *number*, the acuminating planes being either *equal* to or *fewer* than those of the primary form with which they are associated. Acumination by three planes occurs in the hexahedral prism of calcareous spar and garnet, and in the trihedral prism of tourmaline; by four planes, in the tetrahedral prism of jargon and hyacinth, in the octahedral prism of topaz, and in the double octahedral pyramid of garnet, leucite, and native gold; by six planes, in the hexa-

hedral prism of calcareous spar and rock-crystal, and in the simple hexahedral pyramid of light-red silver ore; by eight planes, in tetrahedral prismatic tinstone crystals from Cornwall, in tetrahedral prismatic topaz, and in octahedral prismatic dark-red silver ore.

2. Their relative *size*, which is *equal* or *unequal*. In quartz and rock-crystals the planes of acumination are generally indeterminately unequal, and in baroselenite determinately unequal.

3. Their *form*; which is *determinate* or *indeterminate*. Determinate acuminating planes occur in prismatic calcareous spar, hyacinth, &c.; and with respect to the form, they are sometimes rhombs, sometimes triangles, and often polygons. Indeterminate acuminating planes are found in the crystals of jargon and wolfram.

4. Their *application*; the acuminating planes being set either on the lateral planes, or on the lateral edges, of the primary form, and in both cases either *directly* or *obliquely*. This is an essential difference in many crystals. Both jargon and hyacinth occur in tetrahedral prisms acuminated by four planes, but differ in the application of the planes of acumination, which in the former are set on the lateral planes, and in the latter on the lateral edges.

(*c*) The *summit* of the *acumination*; which is either *obtuse*, as in hexahedral prismatic garnet; *rectangular*, as in tetrahedral prismatic jargon; or *acute*, as in hexahedral prismatic calcareous spar.

(*d*) The *magnitude* of the *acumination*; to indicate whether the acumination has encroached much or little on the primary form. Thus a crystal is said to be *slightly*, or *deeply*, acuminated. This distinction, however, is confined to the pyramid and cube. Fluor spar is deeply acuminated. The cube, where the angles are acuminated by six planes; and the trihedral pyramid of grey copper ore, and of copper pyrites, is slightly acuminated.

(*e*) The *termination* of the *acumination*, either in a *point* or a *line*. The latter forms the transition to bevelling. The former is by far the most common; the latter occurs in hexahedral prismatic white-lead ore and baroselenite, with

both extreme planes obtusely acuminated by two large and two smaller planes, which terminate in a line.

SECT. 135.—In order to form a more distinct idea of truncation, bevelling, and acumination, let us take a cube, prism, pyramid, or any other perfect primary form, represented in wood, and cut off each of the angles or edges at one stroke, so that in its stead a plane shall appear: this will be truncation. But if the extreme planes, the edges, or the angles of any of these primary forms be cut off with two converging strokes, the one from this side, the other from that, so that two planes arise, which, terminating in a line, shall present an edge: this will be bevelling. And if the extreme planes or the angles be cut off at several strokes, all converging together, so that more than two planes arise, commonly terminating in a point, we shall obtain acumination.

Truncation expresses a single plane; *bevelment*, two planes meeting in an edge; *acumination*, three or more planes meeting in a point.

"Truncation" is also spoken of under the terms "*replacement*," and "*suppression of solid angles*." The variations which the cube undergoes in this way are interesting. A mineral often crystallises in perfect cubes; in cubes *with a triangular plane in place of the solid angle*; or in regular octahedrons, *produced from the cube by the truncation of all the solid angles*. At first sight these forms appear to have no connexion; but the whole system of crystallography is based upon these changes of certain primary forms.—*Wern. Club.*

SECT. 136. *Manifold Modifications.*—Many crystals occur with *manifold* and *repeated modifications*. These are either situated *beside each other*, by which we understand simple variations occurring in one and the same crystal and connected with each other, *e.g.* truncation of the edges, acumination of the angles; or they are placed the *one above the other*, being simple variations of the primary form modified by further variations, as, *e.g.* the bevelling edges may be further bevelled, and these again truncated, &c. Crystals thus variously modified necessarily prove the most difficult to describe.

SECT. 137.—In describing a crystal the number of its

planes in general, and their figure (if determinate), may be mentioned by way of addition; as, *e.g.* cubical galena, with truncated angles, consists of six octangular and four triangular planes.

Sect. 138.—To render the description of a crystal as clear as possible, we may also, in some cases, adopt two different modes of determining it,—the *representative* and *derivative.* By the *representative* is understood a description of a crystal according to its apparent form, such as it seems at the first view; by the *derivative,* a description of a crystal founded on a joint consideration of its derivation and of its relation or affinity to other crystals of the same mineral. Thus a description of a prismatic crystallisation of tourmaline would be *representatively* an enneahedral prism, and *derivatively* a trihedral prism, with the three lateral edges bevelled: thus also a pyramidal crystallisation of ruby would be *representatively* an unequilateral and equiangular hexagonal table, with the extreme planes alternately set obliquely on the lateral planes; and *derivatively,* a simple trihedral pyramid with the angles of the base slightly truncated, and the summit so deeply truncated that the large truncating plane conjoins with the smaller. The latter method, viz. the derivative, is undoubtedly the most applicable, being the most easy and intelligible, and, indeed, the best adapted to the nature of the subject. Generally speaking, however, our best guide in determining the primary or fundamental form of a crystal is to consider,—the *figure* and *relations* of the planes; the degree of *regularity* of the crystal in relation to its primary form; the most *frequent occurrence* of the crystal; the *affinity* which it bears to the other crystals of the same mineral; the *suitableness* and *peculiarity* of its modifications; and the *greatest simplicity* in the mode of determination.

Sect. 139. *Transitions from one primary form into another.*—Through the forementioned modification of the primary form a gradual *transition* takes place from one primary form into another; and this in proportion to the increased extent of the modifying planes, and the increased

extent of the primary planes. Indeed, when the modifying planes approach nearer to the centre of the crystal than the primary planes, they become planes of the primary form; and conversely, the primary planes, when more distant from the centre of the crystallisation than the modifying planes become planes of the truncation, acumination, and the like. A few examples will illustrate the subject. Galena has five crystals, through which it passes from the perfect cube into the perfect double tetrahedral pyramid, or octahedron. The perfect cube is its first crystal; the second is the cube with slightly truncated angles; the third is the cube with the angles so deeply truncated that the planes of truncation conjoin, forming the transition from the cube into the double tetrahedral pyramid, and which may be considered either as a deeply-truncated octahedron, or as a deeply-truncated cube: by extending the truncating planes we shall have the fourth crystal, or the double tetrahedral pyramid with truncated angles, in which, therefore, the truncating planes of the cube have actually become the primary planes of the octahedron, and conversely the primary planes of the cube have become the truncating planes of the octahedron, and thus a transition from the cube into the octahedron has already taken place; by extending the truncating planes still further, so that the primary planes disappear, we shall have the fifth crystal, or the perfect double tetrahedral pyramid, in which the primary planes have totally disappeared, and the truncating planes only remain, now constituting the primary planes of the octahedron. The octahedron may also be considered as the first crystal of galena following its transition into the perfect cube through the intervening crystals.

This illustration perfectly coincides with the explanation given in the note on Sect. 135; the greater number of intermediate forms depending solely on the size of the triangular planes by which the solid angles have been replaced.—*Wern. Club.*

[illegible]rther, the oblique angular tetrahedral prism of ar-
[illegible] with obtusely-bevelled extreme planes (the

bevelling planes being set on the acute lateral edges), passes gradually into the octahedron, accordingly as the prism becomes shorter and the bevelling planes approach nearer to each other, so that at last their points conjoin. Here the bevelling is the cause of transition, as in the preceding instance it was the truncation.

Lastly, as examples of transition by acumination we may mention, the tetrahedral prism of tinstone acuminated by four planes (the acuminating planes being set on the lateral planes), which passes into the octahedron, when the planes of acumination become more extended than the primary planes of the prism, the latter at length disappearing entirely; the tetrahedral prism of garnet acuminated by four planes (the planes of acumination being set on the lateral edges), which passes into the dodecahedron with rhomboidal planes, when the prism becomes so short that the acuminating planes conjoin; and thus, also, the hexahedral prism of rock-crystal acuminated by six planes, and the hexahedral prism of calcareous spar acuminated by three planes, pass—the former into the double hexahedral pyramid, and the latter into the double trihedral pyramid.

These examples may suffice to show the transition from one primary form into another by means of truncation, bevelling, and acumination.

Sect. 140.—But transition from one primary form into another may take place also from other causes, as from a change in the relative size of the planes, from a change in the angles under which the planes are associated, from the convexity of the planes, and from the aggregation of crystals. Transitions by a change in the relative size of the planes occur in crystals of apatite, which, according to the greater extent of the lateral or of the extreme planes, may be termed hexahedral prisms or hexagonal tables; and transitions by the aggregation of crystals occur in perfect hexagonal tables of prasium, which, being aggregated by their lateral planes, form hexahedral prisms; and in perfect rectangular quadragonal tables of yellow-lead ore, which, adhering laterally to each other, form cubes.

SECT. 141.—In determining the form of crystals, various difficulties frequently present themselves; for sometimes they appear *compressed*, some planes being uncommonly large or small; sometimes they are found *penetrating each other*, as in tinstone crystals; at other times they are found *partly concealed*, inhering in other minerals, which is often the case with felspar, hornblende, and garnet; and oftentimes they occur *broken*, which is often the case with respect to crystallised precious stones; and, lastly, they sometimes occur *too minute* for description,—in which case, however, the microscope may casually render some service.

3. *The Aggregation of Crystals.*

SECT. 142.—We now come to consider the *aggregation* of crystals, by which is understood whether a crystal is connected or unconnected with another mineral or crystal. In this point of view all crystals occur either *single* or *aggregate*.

Single crystals are found,—

1. *Loose* or *detached.* Most probably these were formerly inlaid in another mineral, but became in course of time detached from it. Precious stones and rock-crystal are often found in this state; also topaz, octahedral red copper ore from Siberia, cubical martial pyrites, and many others.
2. *Inhering* or *inlaying.* Ex. Crystals of felspar in porphyry, hornblende in basalt, and hexahedral prismatic quartz in gypsum.
3. *Adhering;* either by one end or side, and in such a manner that at the part of adherence the completion of the crystal is wanting. Ex. Simple pyramidal and prismatic crystals of quartz, prismatic crystals of arsenical pyrites, and many others.

Aggregate crystals are *regular* or *irregular*.

Regular aggregates consist of a fixed number of crystals aggregated in a determinate manner. Ex. *Twin* and *triple crystals.*

A *twin-crystal* is formed of *two* crystals of the same

mineral, and is distinguished by the re-entering angles. Ex. Staurolite, ort he cross crystal of St. Andreasberg in the Hartz, consisting of two very broad rectangular tetrahedral prisms, each of which is acuminated by four planes which are set on the lateral edges, and the two prisms intersecting each other longitudinally at right angles, form re-entering right angles; 2. the twin-crystal of gypsum, composed of two hexahedral prisms (each prism consisting of two broad and four narrow lateral planes, with the extremities bevelled, and the bevelling planes obliquely set, yet parallel to each other, on the broad lateral planes), and aggregated in such a manner by two narrow lateral planes, that the bevelling planes form at one extremity a salient, and at the other a re-entering, angle; 3. the twin-crystals of ruby, composed of two simple trihedral pyramids attached by their bases, with the angles of the base slightly truncated (and hence forming at the base obtuse re-entering angles), and the summits of both pyramids so deeply truncated as to present rather a *tabular* appearance. The two pyramids are sometimes also so disposed by their bases upon each other, that the angles of the one project over the sides of the other. Sometimes the summit of only one of the pyramids is deeply truncated, in which case the twin-crystal has the appearance of a simple trihedral pyramid, with the angles and summit slightly truncated, possessing at the base an equiangular but unequilateral hexagonal table, whose extreme planes are alternately obliquely set on the lateral planes.[1]

A *triple crystal* is formed of *three* crystals of the same mineral. These are very rare, and have hitherto been found only in calcareous spar and ruby. The triple crystal of calcareous spar is composed of an equilateral hexagonal

[1] Romé de l'Isle has shown that the twin-crystal of ruby arises from the section of an octahedron in an oblique direction, parallel to two opposite planes of the two pyramids; the situation of the two halves of the octahedron being changed in relation to each other. Vid. "Crystallog." tom. ii. p. 227, var. 7. Vid. also Haüy's "Traité de Minéralogie," tom. ii. p. 449, Spinelle transposé.—*Trans.*

table, with an equiangular but unequilateral hexagonal table adhering to either lateral plane; the triple crystal of ruby is in other respects the same as the last-mentioned modification of the twin-crystal, only that to one of the lateral planes of the slightly truncated pyramid there adheres an elongated hexagonal table, with alternate obliquely applied extreme planes.

Irregular aggregates are composed of an indeterminate number of crystals, *singly* or *doubly* aggregated.

Aggregates consisting of many *singly* aggregated crystals may be distinguished into such as are,—

1. *Heaped one upon another*, which occur only in crystals of equal dimensions, and particularly in those of galena, baroselenite, calcareous and fluor spars.

2. *Adhering laterally one to another*, with axes nearly parallel to each other. Ex. Amethyst, and acicular baroselenite.

3. *Implicated one in another*, in the case of crystals of unequal dimensions. Ex. Grey antimonial ore, and hexahedral prisms of calcareous spar.

Aggregates composed of many *doubly* aggregated crystals may thus be distributed, according to the form they assume:—

1. *Scopiform*, consisting of laterally aggregated needle-like and capilliform crystals, diverging from a common centre. Ex. Red antimonial ore, zeolite, striated red cobalt ore, and capilliform pyrites.

2. *Fasciform*, or double scopiform, with a common centre. It occurs in calcareous spar from Gersdorf; also in zeolite and prehnite.

3. *Acicular*. Elongated equally thick prisms, adhering laterally together. Ex. Acicular baroselenite and white-lead ore.

4. *In a row*. Frequent in quartz and calcareous spar.

5. *Bud-like*. Simple pyramids, whose bases are connected or penetrate each other, and whose points are directed towards one another. We have bud-like drusen of quartz and calcareous spar.

G

6. *Globular*. A casual aggregation, consisting mostly of tables or cubes.

7. *Amygdaloid* Drusen of baroselenite, particularly from the Isaac near Rothfurt, which consist internally of a large hexagonal table, on which are externally accumulated smaller tables upon smaller.

8. *Pyramidal*. In prisms, nearly parallel, with summits inclining a little toward each other. The central prism is the highest—very common in calcareous spar.

Our author has added another distinction: *rose-like*, which falls naturally under the head "implicated in one another."—*Wern. Club.*

4. *The Magnitude of Crystals.*

Sect. 143.—The fourth and last subject to be considered with respect to crystals is their *magnitude*. In *what respect*, and in *what manner*, is their magnitude to be determined?

Sect. 144.—There are three dimensions to be determined,—the *length*, the *breadth*, and the *thickness*. But the length of the prism and of the pyramid is termed the *height*; and in every crystallisation the two greater dimensions, if equal, are generally termed the *breadth*; and the two smaller, if also equal, the *thickness*.

Sect. 145.—The manner in which their magnitude may be determined is by comparison with some other assumed quantity, which is called the *measure*; for which purpose I have assumed seven degrees, whose relations are derived from the magnitude of crystals themselves, and which may be employed in ascertaining their size in each species of minerals. These I have determined, not only by mentioning the crystallisations to which they principally belong, but also by showing nearly the relation which they bear to our customary measures in common life. They are the following:—

1. *Of an uncommon size; i.e.* exceeding two feet. I have not met with any occurring of this size besides quartz and rock-crystals.

2. *Very large; i.e.* between two feet and six inches.

3. *Large; i.e.* between six inches and two inches.

4. *Of a middling size; i.e.* from two inches to half an inch in length.

5. *Small; i.e.* between a half and an eighth of an inch. Most crystals are found of this and the preceding size.

6. *Very small; i.e.* between an eighth of an inch and such a size as renders the form still distinguishable by the naked eye.

7. *Minute; i.e.* not distinguishable by the naked eye.

SECT. 146.—The greatest dimension should first be determined; and the smaller dimensions should be determined in relation to the greater.

SECT. 147.—I will only farther observe on this subject, that a greater number of crystal forms occurs in one species than in another. Thus, for example, baroselenite, calcareous spar, garnet, martial pyrites, galena, and gypsum.

Crystallography is important for several reasons: 1. in the discrimination of mineral forms, many minerals being thus determined *at sight*; 2. in relation to chemistry, for the purification of various laboratory products; the extracting of metals (silver from lead) by *cupelling*. It is ineffectual as the basis of any system of arrangement, although this has been attempted more than once; the object of classification should be the developement of natural analogies and relations in respect to chemical composition.

Professor Chapman has adopted a system of describing crystals *by signs*:—

"It consists in marking down the number of the system to which the crystal under examination belongs; secondly, the chief form of that system from which it may have been derived; and thirdly, the modifications which this form may be supposed to have undergone to produce the crystal under examination. This may be done by using, for the third place, the signs given below; and setting down, in the second place, merely the first letter or two of the principal forms mentioned above.

"Thus,—1, C, signifies *cube*; 1, O, *regular octahedron*; 2, P 4, the *square four-sided prism* of the *second* system; 3, Py 6, the *six-sided pyramid* of the *third* system.

"To express the modifications are the following:—

T, or *t*, large or small truncations.
B, or *b*, large or small bevellings.
A, or *a*, large or small acuminations.

"The number of the acuminating planes must be marked afterwards, as A 6, or *a* 6.

"These letters are to be placed above, and separated by a line (in the manner of fractions) from those which follow.

p, planes.	*l*, lateral.
e, edges.	*t*, terminal.
a, solid angles.	+ obtuse, — acute.

"Thus $\frac{T}{2+l\,e}$ signifies *deeply truncated* in the *two obtuse lateral edges.*

"The cube truncated deeply on the angles, 1, C, $\frac{T}{a}$.

"The regular octahedron slightly bevelled on all its edges, 1, O, $\frac{b}{e}$

"The four-sided square prism, having its terminal planes replaced by a large four-sided pyramid, 2, P 4, $\frac{A\ 4}{t\ p}$."

This method possesses the advantage of requiring, when intended for press, merely the ordinary type of the printing-office. *See* also Griffin's "System of Crystallography."—*Wern. Club.*

4. *Extraneous Forms, or Petrifactions.*

Sect. 148.—By *extraneous forms*, are understood those figures of solid bodies which owe their origin to the animal and vegetable kingdoms. They are also called *petrifactions*, and comprehend those organic bodies and their parts which are found, in or under the surface of the earth, retaining either wholly or in part their ancient form, though penetrated throughout with earthy, siliceous, metallic, or bituminous particles.

Sect. 149.—To the term *petrifaction*, however, a much more extensive signification is in general annexed, as implying not only real petrifaction, but also *calcined* substances of the animal kingdom (*fossil bones* or *shells*), *impressions* of animal and vegetable bodies (*typolithi*), and even *incrusted* substances (*tufa*).

Sect. 150.—It is the immediate province of geognosy to consider petrifactions in their most interesting relations, which, when viewed in a proper light, tend greatly to illustrate the history of the earth, as indicating the various

and successive general and partial catastrophes to which it has been subject. Oryctognosy, on the other hand, has no further concern with petrifications than as far as fossils appear in extraneous forms, having by a substitution of particles assumed the figures of animal and vegetable substances; hence a cursory view of petrifactions in general is sufficient for our present purpose.

SECT. 151.—Numbers of fossils, however, are found whose originals either do not or are not known to exist in the animal and vegetable kingdoms; many, perhaps, being removed beyond the observation of mankind by inhabiting the greater depths of the ocean. These are commonly classed among those productions of nature to which they seem most nearly allied.

This paragraph refers to extinct genera or species of animal or vegetable productions; among them are many individuals entirely unknown in the days of Werner; particularly the plesiosaurus, ichthyosaurus, &c., pterodactyle, &c. (see Sect. 161). The progress of geological science and discovery has brought very many new forms to light since his time, whose adaptation to the circumstances under which they existed was most wonderful, but of which not so much as a conjecture had been formed until several years after this treatise was written.—*Wern. Club.*

SECT. 152.—Of those fossils whose originals are known, some are found in the same countries in which their originals exist, as, *e.g.* the petrifactions derived from every class of the animal kingdom, and the various impressions of vegetables, so commonly met with in the slaty limestone of Oening: others, on the contrary, are found in countries far remote from those inhabited by their originals, as, *e.g.* the fossil remains of the elephant, rhinoceros, and other Indian animals, so frequently dug up in the northern regions of the earth.

This would indicate a total change in the temperature of the countries where these remains occur, which took place at some very remote period. —*Wern. Club.*

SECT. 153.—Petrifactions are either *animal* (zoolites) or *vegetable* (phytolites).

Animal petrifactions are those of *mammalia*, *birds*, *amphibia*, *fishes*, *insects*, or *vermes*.

Sect. 154.—Petrifactions of mammalia are those of *men*, *land animals*, and *sea animals*.

It is matter of great doubt whether those which have been considered human petrifactions are derived from the human race.

The only fossil human skeleton is from Guadaloupe (in calcareous stone), and may be seen in the British Museum; but it is only from an *alluvial* formation. The bones contain part of their animal matter, and all their phosphate of lime.

Our author refers, however, to Scheuchzer's "Urweltlicher Mensch," described as a human skeleton, but really only a gigantic species of salamander or proteus.

Plater (1577) described several fossil bones of the elephant found at Lucerne as those of a giant nineteen feet high!! Spallanzani describes a hill of fossil human bones in the island of Cerigo, but this has been disproved by Blumenbach.—*Wern. Club.*

Complete petrifactions of land animals are rarely, if ever, found. They are calcined, and not petrified; seldom in the solid rock, but commonly only penetrated or incrusted with some mineral substance; occurring for the most part in alluvial countries, or in caverns. Bones (*osteolites*) and teeth (*odontilites*) are most common. Thus the bones and teeth, and sometimes the skeletons, of the elephant and rhinoceros, are found in Siberia, and near Burg Tonna in the Gotha dominions, imbedded in marl; the bones of bears occur in great quantities in the Baumann's cavern in the Hartz, and in the Dragon's cavern in the Carpathian mountains. The bones also, and even skeletons, of an immense unknown animal, commonly termed the mammoth, or carnivorous elephant, are found in North America, in Siberia, Germany, and Upper Italy.

There are very many extinct genera and species of animals known to us through geological research alone. Of these the greater number belong to the order *Pachydermata*: viz. the *Paleotherium*, *Anoplotherium*, *Lophiodon*, *Anthracotherium*, *Cheropotamus*, and *Adapis*. They most nearly resemble the tapirs of South America and other warm latitudes.

In the gypsum of Montmartre, near Paris, the remains of so large a number of animals have been found that we insert them here:—

Pachydermata.—Palæotherium, Anoplotherium, Cheroptamus, Adapis.

Carnivora.—Bat, wolf, fox, coati, racoon, genette.

Marsupialia.—Opossum.

Rodentia.—Dormouse, squirrel.

Many other genera are found in other strata, and in the bone caves of this country and the Continent: viz. the cavia and mouse in the slaty limestone of Œningen and Bohemia; the bear, cat, weasel, megalonix, &c., in the limestone caves of Europe and America; the elk, boar, and ox in the peat bogs; and the mastodon, megatherium, horse, elephant, rhinoceros, hippopotamus, tapir, dinotherium, beaver, in the alluvial and detrital deposits of the tertiary period.—*Wern. Club.*

Parts of sea animals, also, are commonly met with, as the bones and teeth of seals, sea-oears, and sea-cows; as also of the whale in Peter's Mount near Maestricht, and an entire skeleton has been found near Quebec in North America.

Sect. 155.—Petrifactions of birds (*ornitholites*) are rare, and, in general, only single bones. Skeletons of aquatic birds are sometimes met with in limestone near Oening, and in slaty limestone near Aichstätt.

The fossil here spoken of as occurring at Oening is the pterodactyle, which has been considered successively as a bird, a species of bat, and a flying reptile. Eight species have already been discovered, and they belong to the order Saurians, adapted by a peculiarity of structure to fly in the air.

The bones of a wader, larger than the common heron, have been discovered in the fresh-water formation of Tilgate forest; foot-prints of birds have also been found in the new red sandstone of Connecticut; bones of the starling, quail, tern, some waders, and pelican, have been discovered by Cuvier in the Paris basin; and more recently those of a large extinct gigantic bird in New Zealand.—*Wern. Club.*

Sect. 156.—Petrifactions of amphibious animals (*amphibiolites*) are still more rare. Fossil shells (*carapaces*) of the tortoise have been found, with bones of the elephant and rhinoceros, near Burg Tonna; fossil frogs and toads are sometimes met with at Oening; and lizards in the bituminous marl of Mansfield. An extinct reptile, bearing relation to the crocodile, has been found in aluminous shale

(*lias*) among ammonites on the sea-coast near Whitby in Yorkshire, and in compact limestone near Blenheim.

Fossil reptiles are exceedingly abundant in some of the rocks of the secondary period: they are the remains alluded to in this section as those of "an unknown reptile."

Cuvier applied to them the distinctive term "*Saurus*." The species are numerous; viz. Plesiosaurus, Ichthyosaurus, Mosasaurus, Pterodactyle, Megalosaurus, Hylæosaurus.

Beside these, the remains of crocodiles have been found in the London clay of Sheppey and elsewhere; of the iguanodon in the Wealden of Sussex; and fossil Chelonians (tortoises) in the muschelkalk of Luneville, the Wealden, London clay, and tertiary lacustrine and marine deposits. The remains of land-tortoises are more rare. The salamander referred to in the note to Sect. 154 falls under this head.—*Wern. Club.*

Sect. 157.—Fossil fishes (*ichthyolites*) are infinitely more numerous than the preceding, being either complete fishes, skeletons, or simple impressions; sometimes, however, single parts only are found. Ex. *Glossopetræ* (teeth of sharks), and *bufonites* (the supposed teeth of the wolf-fish). Some are allied to existing genera. Ex. The fresh-water fish of the Mansfield bituminous marlite, and of Oening limestone; and the salt-water fish of the Pappenheim limestone; but most of them are extinct genera.

Complete fossil fishes occur in the bituminous marl of Thuringia. Skeletons are found in the slaty limestone of Pappenheim; and simple impressions are very common in the bituminous marl of Mansfield, often invested with copper pyrites.

Fossil fishes are exceedingly numerous in secondary and tertiary rocks.

Professor Agassiz has already extended the number of fossil fishes to two hundred genera, and more than eight hundred and fifty species. No existing genus is found among the fossil fishes of any stratum older than the chalk formation. In the inferior chalk there is one living genus, *fistularia;* in the true chalk, five; and in the tertiary strata of M. Bolca, thirty-nine living genera, and thirty-eight which are extinct.

M. Agassiz divides them into five orders:—Placoidians (or *broad-plated*); Ganoidians (or *splendid*, from the surface of the enamel); Ctenoidians (or *jagged scales*); and Cycloidians (or *circular scales*).

The genera terminate abruptly with the various strata, and no one species has yet been found which is common to two great geological

formations. Sauroid fishes and sharks are numerous, and various genera are found in the carboniferous magnesian limestone, muschelkalk, lias, oolite, chalk, and tertiary formations, into a minute description of which it is not our present purpose to enter.—*Wern. Club.*

SECT. 158.—Fossil insects (*entomolites*) are rare. Fresh-water insects are found in Oening limestone. Ex. The larvæ of the dragon-fly and water-scorpion. Salt-water insects (ex. Sea-crabs and the Monuculus polyhemus) in Pappenheim limestone. Trilobites (Entomolitbus *paradoxus*, Linn.), an extinct order, are found near Prague in Bohemia, and in compact limestone near Dudley in Worcestershire, and are known by the name of *Dudley fossil.*

Two coleoptera have been discovered in the ironstone of Coalbrook Dale, and the wing of a corydalis. Wing-covers are frequent in the oolitic slate of Stonesfield. Count Munster has described twenty-five species of fossil insects from the jurassic limestone of Solenhofen. Coleopterous insects allied to the *buprestis* of warm latitudes are common in the former, whilst in the latter, five species of the existing family of Libellula, and numerous coleoptera, have been discovered.

In the tertiary gypsum of fresh-water formation at Aix, sixty-two genera of the orders Diptera, Hemiptera, and Coleoptera have been discovered, all of which Mr. Curtis ("Edin. New Phil. Journ." Oct. 1829) refers to European forms, and most of them to existing genera.—*Wern. Club.*

SECT. 159.—Fossil vermes (*helmintholites*) are most numerous, but are mostly extinct species. They are most frequent in calcareous substances, more rarely in argillaceous, and still more rarely in siliceous.

SECT. 160.—Fossil testacea are extremely numerous in rocks of a secondary formation. They are found calcined; and sometimes mere impressions, or their nuclei, are met with; many are extinct forms.

M. Deshayes and Lyell have also proposed a fourfold division of the marine formations of the tertiary series, founded on the proportions which their fossil shells bear to marine shells of existing species—in the formation of the older and newer pleiocene; taken together, the majority of the shells belong to living species.—*Wern. Club.*

Testacea are *multivalve*, *bivalve* (conchites), or *univalve* (cochlites); fossil multivalves are rare.

Bivalves are more frequent in variety and number. The most numerous and common are—mya, solen tellen, chama, ostrea, anomia, mytilus, pinna. Some are found complete, with both valves entire and close; as mya, anomia, and mytilus; others incomplete, with valves separated, as tellen and chama. The superior strength of hinge, or the greater power of the animal, would account for this.

Univalves possess more or less of a regular spire; bulla, voluta, buccinum, strombus, murex, turbo: of the latter—patella, dentalium, orthoceras. Ammonites (which are most numerous, from the dimensions of a cart-wheel to a very small size) and orthoceratites are extinct forms allied to the nautilus, being chambered shells.

This classification of testacea has been set aside by that of Cuvier, who divided them into the six classes—Cephalopoda, Pteropoda, Gasteropoda, Acephala, Brachiopoda, Cirrhopoda.—*Wern. Club.*

SECT. 161.—Fossil crustacea include echinus, encrinites, and pentacrinites.

Complete fossil echini are rare, the body and spines being generally found detached from each other. The most usual fossils are nuclei of siliceous substances, flint, chalk or calcareous matter, though most frequently imbedded in chalk. Several echinites are extinct forms.

Complete fossil encrinites (head or body, pentagonal articulated stem, and cylindrical jointed arms) are extremely rare. Asteriæ or star-stones (single or jointed parts of the main stem) are common. The head, with six dichotomous branches closed up together, bearing some resemblance to the form of a lily (lily-stone) is rare. Trochites, also called St. Cuthbert's beads, are the single joints; the entrochites (wheel-stones), parts of the jointed stem, being, like the arms, cylindrical.

Pentacrinites are extremely rare. The pentacrinite, an extinct form, consists of a large body divided into many branches, and affixed to a simple jointed stem, destitute of arms.

To use Buckland's words ("Bridg. Treat. Geology," p. 414), "Volumes

might be filled with descriptions of fossil species of those beautiful genera of radiated animals, whose living representatives crowd the waters of our present seas." They are classed under the heads — Echinidans, Stelleridans, Crinoïdans.— *Wern. Club.*

SECT. 162.—Fossil corals (many of which are extinct forms) either appear in arborescent forms, being generally termed corallites ; or they present the appearance of sponges or fungi (fungites). They occur in compact limestone, sometimes siliceous, but more commonly calcareous.

Fossil corals, or polyparies, abound in the transition strata (corals are the productions of polypes)—they extend from the earliest transition rocks to the present seas.— *Wern. Club.*

SECT. 163.—Fossil vegetables are much more rare than those of animals.

Such is fossil wood ; the trunk, branches, or roots of trees, fossilized by siliceous substances, as woodstone, jasper, hornstone—more rarely by calcareous or ferruginous—and generally imbedded in sand, clay, marl, &c. The texture of the wood is so preserved that the species may be ascertained.

Impressions of vegetables are not uncommon in the carboniferous strata.

It is very doubtful whether any fossil inflorescence has been met with ; and fossil fruits, seeds, or seed-vessels, are rare.

Fossil vegetables are distributed in groups, each pointing to successive diminutions in temperature. In *transition strata* a few existing families of endogens (ferns and equisetaceæ) are mixed with extinct families of endogens and exogens; in *secondary strata*, cycadeæ and coniferæ; in tertiary deposits, most of the former disappear, and are succeeded by a complicated dicotyledonous vegetation.— *Wern. Club.*

2. *The External Surface.*

SECT. 164.—The *external surface* is the next *character* observable *by the sight.* In speaking of "external *form*" we understand the relation which single surfaces bear to each other in respect of shape and position ; but in speaking of "external *surface*," we consider these surfaces according

to their inequalities. The external surface is either *uneven, granular*, *drusy*, *rough*, *scaly*, *smooth*, *streaked*, or *rugose.*

Sect. 165.—*Uneven* consists of small irregular elevations and depressions. Ex. Calcedony, and crystals of galena.

Sect. 166.—An external surface of very small, round, and equal elevations is *granular*. Ex. Reniform and stalactitiform brown hæmatites.

Sect. 167.—*Drusy*—Very small and minute prominent crystals, nearly equal to each other. Ex. Hexahedral prismatic, martial pyrites.

Sect. 168.—*Rough*— Minute and almost imperceptible elevations, sometimes sharp, sometimes blunt. Ex. Cellular quartz, rock-crystal pebbles, coralliform stalactite.

Sect. 169.—An external surface composed of slender splinters, or small thin flakes, resembling scales, is said to be *scaly*. Ex. Chrysolite surface.

Sect. 170.—An external surface, entirely destitute of elevations or prominences, is said to be *smooth*. Ex. Specular hæmatites, cubical galena, cubical fluor spar, and many others.

Sect. 171.— *Streaked* —consists of small and almost imperceptible parallel elevations in one straight direction, and occurs almost solely in crystals. *Singly-streaked* surfaces are,—

1. *Transversely-streaked*—when the streaks run parallel with the breadth of the lateral planes, as in rock-crystals.

2. *Longitudinally-streaked*—when the streaks run parallel with the length of the lateral planes. Ex. Topaz from Schneckenstein, prismatic shorl, &c.

3. *Diagonally-streaked*—when the streaks run parallel with the diagonal of the lateral planes. Ex. Cubical cinnabar from Almada, cubical specular iron ore from Altenberg.

4. *Alternately-streaked*—when the streaks of a crystal run parallel with the sides of its planes, differing in direction with those of the adjoining planes, and preserving the same direction with those of the opposite planes, as in cubical martial pyrites with a streaked surface.

Doubly-streaked surfaces are :—

1. *Plumiformly-streaked*—when the streaks from two opposite points meet under an acute angle in a straight line, which forms the division between them, thus bearing some resemblance to a feather, whence the denomination is derived. Ex. Native silver from Mexico, and in native bismuth.

2. *Retiformly-streaked*—an external surface presenting several straight streaks, resembling slight incisions, which are partly parallel with, and partly intersect each other at right angles. It must not be confounded with *retiform*, which was noticed among the particular external forms, and to which it bears some resemblance. Grey cobalt ore and native silver only have been found with a retiformly-streaked surface.

Streaked surfaces often arise from a close fibrous structure, or otherwise indicate the direction of cleavage planes.—*Wern. Club.*

SECT. 172.—*Rugose* consists of several very slight linear elevations, forming different irregular curves. Ex. Calcedony and crystals of calcareous spar.

3. *The External Lustre.*

SECT. 173.—The external lustre is the *third particular generic character* of solid minerals, and the last of the external appearance. As the lustre which we observe on the *external* or natural surface of a solid mineral, as well as on that of a friable or fluid mineral, is the same as that which appears on its *internal* surface, and is determined in the same manner; the difference being only that in the one or the other species or variety the lustre is stronger or weaker externally than internally.

By *lustre in general* is understood the relation which a mineral bears to that reflection of light which is caused, partly by a smoothness of the surface, or at least of the aggregated parts which constitute the surface, and partly by its density. The former is the cause of the different degrees of *intensity*, the latter of the different *kinds* of lustre.

This character is not of much service, since the distinction between external and internal lustre is difficult to be drawn: it bears the same relation to transparency as *reflected* does to *refracted* light.—*Wern. Club.*

SECT. 174.—The *intensity* of the *lustre* cannot be determined in any other manner than by certain assumed degrees. I have adopted the five following: *resplendent*, *shining*, *weakly-shining*, *glimmering*, and *dull*.

Chapman adopts the following distinctions:—

Dull. Ex. Chalk, clay.
Glimmering. Ex. Massive chlorite.
Glistening, or weakly-shining. Ex. Native arsenic.
Shining. Ex. Rock-crystal.
Splendent, or strongly-shining. Ex. Galena.—*Wern. Club.*

SECT. 175.—A mineral presenting a dazzling lustre at a considerable distance is said to be *resplendent* or specular. Ex. Native quicksilver, crystals of grey antimonial ore, &c.

SECT. 176.—A mineral is said to be *shining* when its lustre is not so distinct when observed closely. It is generally accompanied by an uneven fracture. Ex. Grey copper ore, and the fracture of vitreous copper ore, sulphurated nickel, arsenical pyrites.

SECT. 177.—*Weakly-shining*—when feebly perceptible at a short distance only. Ex. Magnetic ironstone, native silver, and fibrous gypsum.

SECT. 178.—*Glimmering*—arises from the minute aggregations reflecting a feeble light. Ex. Earthy talc, grey cobalt ore, flint, and steatite.

SECT. 179.—*Dull*—when destitute of lustre. Ex. Most friable minerals and solid earthy minerals.

SECT. 180.—The *kind* of *lustre* differs according to the greater or less degree of density. There are two kinds, *common* and *metallic;* the former belonging to earths, stones, and salts, and distinguished into,—

1. *Glassy lustre.*—Ex. Quartz, rock-crystal, calcareous spar, and fluor spar.

2. *Waxy* or *greasy lustre.*—Ex. Corneous silver ore, yellow and green-lead ores, opal.

3. *Mother-of-pearl lustre.*—In zeolite.

4. *Diamond lustre.*—Ex. Diamond, jargon, and white-lead ore.

5. *Semi-metallic.*—Metallic approaching to glassy ; as in mica, and hæmatites.

Metallic lustre is peculiar to most dense mineral substances—metals and the greater part of their ores.

The Internal Appearance.

Sect. 181.—We now proceed to internal appearance, which comprises *the appearance of the fracture*, and *the appearance of the distinct concretions.*

By this we understand the appearance, which does not belong to the external or natural surface, but to the new surface produced by fracture ; *i.e.* the appearance of the surfaces produced on breaking a mineral in any direction except that of its natural cleavage planes.

The Appearance of the Fracture.

Sect. 182.—If a mineral divides *completely through its interior*, and not in the direction of natural rifts or slight fissures, a new surface arises, and all the characters perceptible in it are the characters of the fracture. Here, also, three kinds of characters occur; and these are, the *internal lustre, the fracture,* and the *form of the fragments.*

1. *The Internal Lustre.*

Sect. 183.—The *internal* lustre is therefore the first of those external characters which belong to the appearance of the fracture, and the *fourth particular generic character* observable in solid minerals *by the sight.*

The internal lustre is much more to be relied upon than the external.

2. *The Fracture.*

Sect. 184.—The *fracture*, oftentimes called the structure,

is the *fifth particular generic character*, and the second of those which constitute the appearance of the fracture; it results from that of the minute component particles, too small to be distinguished by the sight.

The internal surface of the fracture either presents the appearance of an uninterrupted (unjointed) solid continuity (*compact fracture*), or it bears the aspect of an aggregation of smaller *distinct parts*, which communicate to the surface a peculiar appearance, the continuity seeming interrupted or jointed. They are called *distinct*, being actually separated, and not admitting, as the *distinct concretions*, a perception of the three corporeal dimensions.

The Compact Fracture.

Sect. 185.—In *compact fracture* no distinct parts are discernible; but the minute particles are, in a manner, uninterruptedly connected with each other. It is the most common kind of fracture, and is further divided into *splintery*, *even*, *conchoidal*, *uneven*, *earthy*, and *hackly*.

Sect. 186.—*Splintery*, when the surface is uninterrupted, but in which small splinters or scales are here and there perceptible by the light transmitted through them to the surface beneath. These splinters are thicker at the end by which they adhere. A certain degree of transparency is always combined with the splintery fracture, even if the mineral is translucent only; otherwise the splinters would not be perceptible. A splintery fracture, combined with resplendency and transparency, or semi-transparency, is called *vitreous*. Splintery fracture passes into the even and uneven, or into conchoidal and earthy. It differs little from the even fracture, so that it might be almost considered as a sub-variety; and it is distinguished into *coarse* and *fine* splintery: of the former kind are most quartz and prasium, jade and coarse splintery limestone; of the latter, hornstone and fine splintery limestone.

Sect. 187.—*Even* fracture is destitute of elevations, and passes into splintery and conchoidal. Minerals with an

even fracture are usually only glimmering, and are never perfectly transparent. Ex. Compact galena, grey cobalt ore.

Sect. 188.—The fracture is *conchoidal* when it consists of flat round elevations and depressions, accompanied with circular wrinkles, possessing a conchoid (*shell-like*) appearance, from which the denomination is derived. Conchoidal is further distinguished into *large* and *small, perfect* and *imperfect, deep* and *flat*. It passes partly into even, uneven, or splintery; when it is shining, it is called *scorious*. Flint, obsidian, and many others, show it most perfectly.

Sect. 189.—*Uneven*—or interrupted by irregular and rather large angular elevations and depressions. It mostly occurs in opaque, shining, and weakly-shining, and is generally accompanied with some lustre. It is either *coarse-grained;* and contrariwise, *small fine-grained:* and passes into conchoidal and even.

Sect. 190.—*Earthy*—when the surface is composed entirely of small rough elevations. Being rough and earth-like, and pertaining chiefly to indurated earths, it is generally destitute both of lustre and transparency; it passes partly into even or uneven.

Sect. 191.—*Hackly*—composed of sharp-pointed parts, protruding from the internal surface, and it is chiefly characteristic of, and peculiar to, metals. Ex. Native gold, native silver, native copper, and native iron.

The Jointed Fracture.

Sect. 192.—In *jointed fracture* particular distinct parts are discernible, actually separated by nature, but not admitting a perception of dimension. Fracture has been distinguished into the *fibrous, striated, foliated,* and *slaty*.

Sect. 193.—*Fibrous*—when certain larger, linear, parts are discernible, and the smallest aggregated parts distinct. Fibrous minerals can scarcely arise otherwise than from a perfect solution; whereas several of the before-mentioned are mere indurations of the friable. It seems, however, as

if those minerals in which it occurs had not been so intimately dissolved as the foliated, since a great part of them arose stalactitically, *i. e.* by a succession of drops, and the remainder are generally found massive, scarcely ever any crystallised. This kind of fracture occurs weakly-shining, or only glimmering. Fibrous minerals are only translucent, and generally opaque. It is further distinguished according to the *thickness*, the *direction*, the *position*, and the *length* of the fibres.

In relation to *thickness*—*coarse*, *fine*, or *delicate* fibrous. Ex. In fine fibrous malachite, black hæmatites, fibrous wood-tin ore, amianthus, coarse fibrous grey ore of manganese, gypsum, and rock-salt, coarse fibrous passes into striated.

In relation to *direction*—*curved* or *straight*. Ex. Black hæmatites, fibrous rock-salt, red hæmatites.

In relation to *position*—*parallel*, *diverging*, or *promiscuous*. Diverging-fibrous is distinguished into *stelliform* and *scopiform*: *stelliform*, when the fibres are directed from a common centre to every side; *scopiform*, when the fibres are also directed from a common centre only to one side or to two opposite sides, the middle fibres being also often longer than the other, and communicating to the whole an elongated appearance.

In relation to *length*—*long* or *short* fibrous.

Sect. 194.—*Striated*—*long* and *narrow* parts resembling planes, laid on and beside each other. These parts are called striæ, and form a mean between fibres and folia. Minerals possessing a striated fracture are frequently shining or resplendent, but never semi-transparent or transparent, and are among the most rare forms. Striated is further distinguished:

In relation to the *breadth* of the striæ—*narrow*, *broad*, or *very broad* striated.

According to the *direction*—*straight* or *curved* striated.

According to *position*—*parallel*, *diverging*, or *promiscuous*.

With respect to *length*—*long* or *short* striated.

SECT. 195.—*Foliated* fracture is entirely composed of folia (naturally distinct parts resembling planes), the length and breadth of which is nearly equal, in a manner laid one upon another. Most foliated minerals are remarkable for a specular lustre reflected from the folia, more specular as the folia separate more evenly and smoothly in breaking. Foliated minerals, particularly those which are perfectly foliated, are produced from the most intimate solution, and with the greatest degree of rest. Most crystals are foliated; and foliated fracture frequently occurs in solid minerals. It is farther distinguished according to the *magnitude*, the *perfectness*, the *direction*, and the *passage* of the folia.

The *magnitude* of the folia is very different, and generally determined by that of the distinct concretions, the folia being in proportion to the extent of the granular distinct concretions. Hence a mineral is said to possess a *large*, *scaly*, or *granularly*-foliated fracture. Scaly-foliated is further distinguished into *coarse*, *small*, and *fine* scaly. It must not be confounded with the scaly external surface. We have scaly-foliated galena, micaceous iron ore, mica, and gypsum. Granularly-foliated is farther distinguished into *gross*, *coarse*, *small*, and *fine* granular. Ex. Granularly-foliated galena, sparry iron ore, micaceous iron ore, blende, calcareous spar, and many others.

As regards *perfectness*—foliation is *perfect*, *imperfect*, or *concealed*. *Perfectly foliated*, when the folia separate smoothly and are specular. Ex. Calcareous spar, yellow blende, and felspar. *Imperfectly foliated*, when the folia separate somewhat unevenly, and are less smooth and shining. Ex. Beryl, topaz, and aquamarine. *Concealed foliated*, when the foliated fracture appears distinct only in a few places. Ex. Emerald.

As regards *direction* (which only relates to the large foliated)—*straight* or *curved*. *Curved foliated* is either *spherically curved*, *undularly curved*, *petaloidally*,—the folia presenting on the internal surface a dull delineation somewhat resembling a cabbage-leaf, as in galena, which has then

the particular property of containing a little silver; or *indeterminately curved.*

Cleavage is a most remarkable property of foliated minerals, the cause of which scarcely admits of a satisfactory explanation. It is the foundation of all regular fragments, and by it is understood the capability which foliated minerals possess of splitting in certain different directions. In such minerals, therefore, a manifold foliated fracture occurs, the folia intersecting each other under different angles, and each particle of such minerals appertaining at the same time to one and several folia. The passage of the folia may be easily observed in such as are transparent, and in fragments of most foliated minerals. It is distinguished, 1. According to the *angle* which one cleavage forms with another into *rectangular* (the most usual case), or *oblique angular;* 2. According to the *number* of the cleavages, as follows:—

1. A *single cleavage* of the folia. This takes place when the constituent folia are laid one upon another in one direction only, in which alone the mineral can be split; hence it possesses only two opposite sides, which are foliated and specular: such are mica and talc.

2. A *double cleavage* occurs in foliations of two different directions, in both of which it may be split. The folia intersect each other nearly at a right angle, thus forming four specular planes, as in felspar and hornblende.

3. A *triple cleavage,* when a mineral splits in three different directions, forming six specular planes, as in calcareous spar, siderocalcite, and sparry iron ore.

4. A *quadruple cleavage,* when foliated in four different directions, as fluor spar.

5. A *sextuple cleavage,* when the folia intersect each other in six different directions, as in yellow, brown, and black blende.

Sect. 196.—*Slaty*—the transition from the compact into the foliated. If it occurred less frequently in the great, and were not confined merely to opaque and glimmering minerals, it might almost be called imperfectly foliated. It forms the

transition into perfectly compact. Argillite shows the slaty fracture very distinctly through all its gradations to the perfectly compact. The slaty fracture is further distinguished from the foliated by the distinct parts possessing a more considerable, but unequal, thickness, by their not separating so smoothly and evenly, and by their not reflecting so strong a lustre. Besides, slaty minerals never split in more than one direction. As regards the *thickness* of the lamellæ, it is *thick* or *thin* slaty; and as regards their direction, it is *straight* or *curved*, and this again *undularly*, or *indeterminately curved*.

SECT. 197.—It is remarkable that in some minerals, possessing distinct parts, two kinds of fracture, or of distinct parts, occur together. Thus we have fibrous gypsum and hæmatite, at the same time both fibrous and foliated. The fibres, in this case, are intersected by the folia at a certain angle, and the integrant particles appertain at the same time both to fibres and folia, the latter intersecting the fibres at right angles.

Before we take our leave of this character it remains to be observed, that it is an error to conceive that all minerals possess one or other of these fractures. So far from this being the case, they sometimes occur with two kinds of fracture, either one *in* the other, or one *beside* the other: thus, some specular gypsum has a conjointly foliated and fibrous fracture; and in topaz, the transverse fracture is foliated, and the longitudinal conchoidal. Such exceptions ought necessarily to be noticed among the characters of minerals.

Fracture is a character of subordinate importance, and for all ordinary purposes of description may be confined to *even*; *conchoidal*; *uneven*, *or indented*; *hackly*.

Earthy is merely a fine-grained, uneven fracture, with dull lustre.—*Wern. Club.*

3. *The Form of the Fragments.*

SECT. 198.—The *form of the fragments* is the *sixth par-*[illegible] *generic character*, and the third of those relating to

the appearance of the fracture. They are distinguished into *regular* and *irregular*. The former can arise only in foliated fractures, and in such as, generally speaking, possess a manifold cleavage. The *regular* are :—

1. *Cubical fragments*, resulting from a triple rectangular cleavage.

2. *Rhomboidal*, arising from a triple oblique angular, or sometimes from a twofold, and even single cleavage. Hence rhomboidal fragments are specular on *all*, on *four*, or only on *two* planes. Rhomboidal fragments, with *all* planes specular, result from a perfect triple cleavage of the folia; those with *four* specular planes from a twofold cleavage; and those with *two* specular planes from a single perfect cleavage of the folia. Rhomboidal fragments occur frequently among solid minerals.

3. *Trapezoidal;* and,

4. *Trihedral pyramidal fragments*, occur together, and originate in a quadruple cleavage of the folia. Trihedral pyramidal fragments, with deeply truncated angles, approach the form of the octahedron. They may be distinctly observed in fluor spar.

5. *Dodecahedral fragments* proceed from a sextuple, obtuse, and nearly equiangular, cleavage of the folia. The dodecahedra, which thus arise, consist of twelve rhomboidal planes. They occur in blende.

It frequently happens that several of the foregoing kinds of fragments cohere together, so that we should not be deceived if their peculiar forms be not immediately obvious.

The *irregular fragments*, which are more frequent than regular, are,—

1. *Cuneiform*, belonging to all minerals with a diverging fibrous fracture, as red hæmatites, wood-tin ore, malachite, &c.

2. *Splintery* (*spicular*), as in parallel fibrous red hæmatites, amianthus, and asbestus.

3. *Tabular*, of an equal length and breadth, but a less thickness, and generally terminating in an edge. Mica, talc, and roofing-slate, break into tabular fragments.

4. *Indeterminate.* These are the most usual, and are distinguished, according to the degree of sharpness which the edges of the fragments possess, into *very sharp-edged,* as obsidian, common opal, and rock-crystal; *sharp-edged,* as hornstone and quartz; *moderately sharp-edged,* as limestone and copper pyrites; *rather blunt-edged,* as steatites; and *blunt-edged,* as chalk and fullers' earth.

Moreover, we should be cautious how we confound the external form with the form of the fragments, which many mineralogists have done, particularly in regard to calcareous spar. I conceive that the different forms of fragments originate in the figure of the smallest aggregated parts, which it may be supposed possess in every kind the same form that the fragments exhibit in the greater. This may be almost maintained with certainty of the cubical, rhomboidal, and pyramidal fragments.[1]

The form of fragments may be divided in *regular* and *irregular,* and are the primary or primitive forms described in Sects. 113–122.—*Wern. Club.*

The Appearance of Distinct Concretions.

Sect. 199.—In observing minerals with attention, we find that several are entirely composed of *distinct concretions;* that is, they are already divided by natural interstices or joints. These distinct concretions are slightly coherent with each other, and the joints are more or less clearly perceptible; the minerals which are so composed generally divide, in breaking, in the direction of these joints. Distinct concretions must not be confounded with crystallisations, fragments, nor with the distinct parts of the fracture, from which latter they are distinguished by a proportionate and determinable extent in length, breadth, and thickness.

Distinct concretions may have been produced in a twofold manner. Either from an intimate solution and consequent tendency to crystallisation, interrupted in its progress

[1] This subject has been put in the clearest light by Abbé Haüy. Vid. "Traité de Minéralogie," vol. i. p. 19, et seq. "Théorie de la "—*Trans.*

by the particles being disturbed, or closely crowded together, forming separate concretions connected in one mass; or from a less intimate solution, or from a diffusion of the mineral in a fluid, in which the concretions arose from a mere mechanical apposition of the parts and from successive depositions, with no tendency to crystallise.

Many minerals never occur with distinct concretions, as chalk, opal, chrysoprasium, &c.; others, on the contrary, scarcely ever otherwise, as galena, zeolite, &c.

The appearance of the distinct concretions comprises also three particular generic characters, viz. *the form* of the distinct concretions, the *surface of separation*, and *the lustre of separation*.

1. *The Form of the Distinct Concretions.*

SECT. 200.—This is the *seventh particular generic character*, and the first of those relating to the appearance of the distinct concretions. According to the different proportion of the single surfaces which compose the complete surface of the distinct concretions, the form is distinguished into *granular*, *lamellar*, *columnar*, and *pyramidal.*

SECT. 201.—*Granular distinct concretions* are those whose three dimensions are nearly equal. They are distinguished, with respect to the *form*, into,—

1. *Round granular;* which are either *spherically granular*, as in roestone and pisolite; *lenticularly granular*, as in acinose argillaceous ironstone from Bohemia; or *elongated round granular*, as in quartz.

2. *Angularly granular;* which are either *common angularly granular* (the most usual), as in galena, calcareous spar, and siderocalcite; or *elongated angularly granular* (which are more rare), as in hornblende, and granular limestone.

In relation to the *magnitude*, into,—

1. *Gross granular.*
2. *Coarse granular.*
3. *Small granular.*
4. *Fine granular.*

When the granular distinct concretions become very minute they approach to the compact fracture.

SECT. 202.—*Lamellar distinct concretions* consist of plates (lamellæ) laid one upon another, adhering more or less strongly to each other. They are distinguished, with respect to their *direction* or *form*, as,—

1. *Straight lamellar.*
2. *Curved lamellar* (indeterminate, reniform, concentric, spherically concentric, or conically concentric).

With regard to *thickness*, as,—

1. *Very thick lamellar.*
2. *Thick lamellar.*
3. *Thin lamellar.*
4. *Very thin lamellar.*

When the lamellar distinct concretions become quite thin they pass into the foliated fracture.

SECT. 203.—*Columnar distinct concretions* occur in those minerals which consist of greater or smaller columns apposed to each other, and are distinguished:—

1. In relation to *direction*—into *straight columnar* and *curved columnar.*

2. With respect to *thickness* (in which particular they differ much, varying from the thickness of a thread to that of several feet)—into *very thick columnar*, exceeding two inches in diameter, as in basalt, quartz, and clinkstone; *thick columnar, thin columnar, very thin columnar.*

3. With regard to *form*—into *perfectly columnar, i.e.* of an equal thickness throughout; *imperfectly columnar, i.e.* short and unequally thick; or *cuneiform columnar, i.e.* slender or pointed toward one extremity.

4. With respect to the *position* of the columns—into *parallel columnar*, as shorlite; or *diverging* or *promiscuous* columnar, as shorl, and arsenical pyrites.

When the columnar distinct concretions become extremely slight, they form the transition to the fibrous fracture.

SECT. 204.—*Pyramidal distinct concretions* are very uncommon, and have hitherto only occurred in basalt in Iceland, Ferro, and Bohemia; they are trihedral or tetrahedral,

rarely pentahedral, and more or less regular. The basalt separates sometimes into simple, sometimes into double, trihedral pyramids, the summits of the latter being mostly very acute angular.

Sect. 205.—Granular, lamellar, and columnar distinct concretions pass frequently one into the other. These transitions are particularly distinct in specular iron ore, in which all three kinds of distinct concretions occur. The transition from granular into lamellar appears also very distinct in galena. Sometimes two kinds of distinct concretions occur together in one and the same mineral, and in such a manner that one *intersects* or *includes* the other.

2. *The Surface of Separation.*

Sect. 206.—This is the *eighth particular generic character*, and the second of those relating to the appearance of the distinct concretions. The *surface of separation* is that which separates the distinct concretions from each other, and is particularly observable when minerals, possessing distinct concretions, break in the direction of that surface. It is a character well marked in some minerals, but does not possess so many varieties as the external surface. It is either *smooth, rough*, *uneven*, or *streaked*, either *longitudinally*, or *transversely* and *fortification-like*.

3. *The Lustre of Separation.*

Sect. 207.—This is the *ninth particular generic character*, and the last of those relating to the appearance of distinct concretions. The term refers to the lustre of that surface which separates the distinct concretions from each other. It must not be confounded with the lustre of the fracture or internal lustre, from which it is very different. Thus, for example, the internal lustre of red hæmatites is weakly-shining, and the lustre of separation resplendent.

It is determined by the same degrees, and in the same manner, as the external lustre.

THE GENERAL APPEARANCE.

SECT. 208.—"General appearance," a term applicable to the exterior and interior of solid minerals, comprehends three particular generic characters,—*the transparency*, *the streak*, and *the stain.*

1. *The Transparency.*

SECT. 209.—*Transparency* is the *tenth particular generic character* observable *by the sight;* and describes the different relation with respect to the transmission or passage of the rays of light.

The free passage of the rays of light in any mineral proceeds from the aggregated arrangement of its molecules: so that it is transparent when its molecules are arranged in such a manner that their interstices succeed each other in perfectly straight directions, thus affording a free passage to the rays of light; or it is opaque when the interstices lie confusedly one among another.

Three things are requisite in order that the molecules may attain that kind of position which will render a mineral transparent: 1st, that the molecules be of a nature capable of assuming such a position; 2d, that in the course of formation the molecules be in a fluid state (*i. e.* intimately dissolved), in order to adjust themselves in the position suitable to their peculiar power of attraction; 3d, that the solution be at perfect rest. For if the nature of the molecules be such as to render them incapable of assuming such a position, they will result in opaque mass. If, on the other hand, the molecules so tend to arrange themselves, but are not sufficiently dissolved, the product will acquire a less degree of transparency according as the solution is less complete. Lastly, if the solution is not quiescent, the molecules will not associate together according to the natural power of attraction.

It is evident that perfect transparency can only be sought in the products of an intimate and undisturbed

solution, as it occurs almost solely in crystals, resulting from the most intimate solution in perfect rest, and are the more regular and transparent the more intimate and undisturbed the solution was from which they proceeded.

One part is often more transparent than another (*e.g.* in quartz crystals, which are frequently transparent at the point, but only translucent at the part of adherence). In these the particles imperfectly dissolved subside: the attractive power of the surface of adherence acting more strongly on these particles by reason of weaker cohesion, corresponding with the less perfect solution, the imperfectly dissolved particles subside, and hence the lowest part of the crystal is the least transparent.[1]

I have adopted the following degrees of transparency:—*transparent, semi-transparent, translucent, translucent at the edges,* and *opaque.*

Sect. 210.—A mineral is *transparent* when objects may be distinctly discerned through it. This highest degree of transparency is generally found only in crystals of earthy minerals. Transparent is distinguished into *common* and *doubling* (double-refracting). Common, when objects viewed through a transparent mineral appear single; double-refracting when they appear double; this, however, occurs only in one mineral, transparent calcareous spar (double-refracting spar).

The variety called "Iceland spar" possesses this peculiar property in an extraordinary degree. Haüy, in his "Traité de Minéralogie," tom. i. pp. 271, 272, instances several other minerals as possessing this property, viz. jargon, crysolite, sulphur crystals, and carbonate of lead. Double refraction arises from the division of the incident rays of light into two others of different powers of refraction. Vid. Newton's "Optics," lib. iii. quæst. 25, 26.—*Wern. Club.*

The diamond, ruby, emerald, sapphire, hyacinth, Bohe-

[1] Wallerius seems to attribute the smaller degree of transparency that sometimes occurs at the base of rock-crystals to an earthy substance mixed in the attenuated solution from which the crystals arose, but settled at the bottom of the crystallisation by reason of its greater weight. —Vid. "Systema Mineralogicum," p. 218, observ. 1.

mian garnet, aquamarine, topaz, crysolite, amethyst, and many others, possess greater or less degrees of transparency.

SECT. 211.—A mineral is *semi-transparent* when objects can be only imperfectly observed through it. Ex. Opal, cornelian, calcedony; sometimes also quartz, and crystals of calcareous spar, and siliceous stones.

SECT. 212.—A mineral is *translucent* when objects cannot be perceived through it; which, however, transmits some light. Sulphur, amber, rock-salt, quartz, and fluor are examples.

SECT. 213.—A mineral is *translucent at the edges* when the light is only perceived by holding it up to the light, and then only at the extremities. It is often confused with opacity. Hornstone, stalactite, felspar, marble, calcareous spar, and foliated gypsum are translucent on the edges.

SECT. 214.—Minerals are *opaque* which do not transmit a perceptible degree of light, even through the smallest and thinnest pieces. This character is frequent, and may be observed in metals, and minerals with an earthy fracture.

2. *The Streak.*

SECT. 215.—When minerals are scraped with a knife, they yield a powder of the *same* or a *different* colour, and the same or a different degree of lustre, as that which they naturally possess. This, called the *streak*, is the *eleventh particular generic character*. I shall only adduce some examples:—The streak of red-silver ore is generally a dark crimson-red; of cinnabar, scarlet-red; of specular iron ore, commonly dark crimson-red, but sometimes closely verging on black; of micaceous iron ore, the same; of wolfram, reddish-brown; of green-lead ore, greenish-white, inclining a little to yellow; of red-lead ore, clear lemon-yellow, verging on orange-yellow; of tinstone crystals, light grey; of black blende, brown, inclining a little to grey; of yellow and brown blende, white, verging on yellow or grey; of black slate, light grey; and, generally speaking, the streak of most variegated and black stones is white or grey, inclining

to the natural colour. This character may oftentimes be observed in an injured or bruised part of a mineral.

3. *The Stain.*

Sect. 216.—The *stain* is the *twelfth particular generic character*, and the third of those which form the general appearance. There are many minerals which both *stain* and *mark*. Ex. Red scaly iron ore, grey ore of manganese, chalk, slate, and plumbago.

In modern writers this character is named "soiling;" it is possessed by decomposed, friable minerals; but few perfect minerals soil.—*Wern. Club.*

The Hardness.

Sect. 217.—Having treated of those *particular generic characters* observable *by the sight*, we now proceed to those which are perceived *by the touch*. Hardness is the first; and in the general arrangement the *thirteenth*.

Sect. 218.—By hardness is understood the resistance to an impressive force, tending to the separation of its integrant particles. Thus gypsum feels more tender than quartz. The consideration of this difference is called by mineralogists "examination of the *hardness*." Minerals are distinguished into *hard*, *half-hard*, *soft*, and *very soft*.

This is one of the most important of mineral characters, but requires some definite scale of comparison. Professor Möhs has introduced such an one, by establishing certain minerals as standards; viz.:—

1. Talc.	6. Adularia felspar.
2. Pure rock-salt.	7. Transparent rock-crystal.
3. Calcareous spar.	8. Topaz.
4. Fluor spar.	9. Corundum.
5. Apatite.	10. Diamond.

Thus, fluor may be described as $H = 4$, or an intermediate degree as $H = 4{\cdot}5$ or $3{\cdot}5$. To establish the degree of hardness, it is advisable to proceed *downwards*, examining the specimen with a file.

Professor Chapman has adopted a still simpler scale, corresponding with the above, viz.:—

1, Yields to the nail; 2, does not scratch a copper coin; 3, scratches a copper coin, and is scratched by it; 4, not scratched by a copper coin, and does not scratch glass; 5, scratches glass, and yields easily to the knife; 6, scratches glass easily, but yields with difficulty to the knife; 7, does not yield to the knife, but yields with difficulty to the edge of a file; 8, 9, 10, harder than flint.—*Wern. Club.*

SECT. 219.—A mineral is *hard* that cannot be scraped with a knife, or gives fire with steel. This degree is found only among perfectly brittle minerals. Minerals are further distinguished, in relation to the impression which they receive from the application of a file, into *hard;* such, namely, on which the file makes a *considerable impression*, as felspar, shorl, and specular iron ore; *very hard*, on which the file makes a *weak impression*, as rock-crystal, topaz, and flint; and *extremely hard*, on which the file makes *no impression*, but rather receives an impression from the mineral, as diamond and emery.

SECT. 220.—A *half-hard* mineral does not strike fire with steel, but may in some measure be scraped with a knife. Such are sparry iron ore, calcareous spar, stalactite, opal, fluor, zeolite, basalt, pitchstone, and many others.

SECT. 221.—*Soft* minerals may be easily scraped with a knife, but suffer no impression from the nail. Ex. Vitreous silver ore, grey-silver ore, common and compact galena, white and green-lead ores, amber, mica, asbestus.

SECT. 222.—*Very soft* minerals may not only be easily scraped with a knife, but also receive an impression from the nail. Ex. Solid cinnabar, sulphurated bismuth, earthy cobalt ores, realgar, sulphur, pit-coal, compact and specular gypsum, talc, steatites, amianthus, chalk, and many others.

SECT. 223.—These several degrees of hardness pass one into the other, in such a manner that each not only occurs very differently modified, but we also frequently meet with minerals possessing two different, yet relative, degrees of hardness, forming the transition of these two degrees. It is therefore proper, in determining the hardness, not only to mention the chief degree, but also the intermediate degree.

The Solidity.

Sect. 224.—This is the *fourteenth particular generic character*, and the second of those observable *by the touch*. By *solidity* is understood the different cohesion of the integrant particles. We thus find that the integrant particles are either coherent and thoroughly immoveable, or coherent and in some measure moveable with difficulty. Thus minerals are said to be *brittle*, *sectile*, or *malleable*.

Those are *brittle* whose integrant particles are in the highest degree coherent and immoveable one among another. These are most frequent, and are distinguished by the fine dust which springs from them on a powerful application being made with the knife. All hard, also many half-hard and soft minerals, are brittle.

Those are *sectile* whose integrant particles are coherent, but not perfectly immoveable. Sectile is a medium between brittle and malleable. In cutting sectile minerals, the separated parts remain together, in some measure resembling flakes or slices. Sectile minerals always acquire a stronger lustre from the streak.

Those are *malleable* whose integrant particles are coherent, and more or less moveable one among another. Such are not only capable of being cut in slices, but of being bent and beaten out. They are never hard, and generally occur with a metallic lustre. Nearly all native metals are malleable.

Malleability is, in a manner, a slight degree of fluidity, forming the transition from solid fossils into fluid.

The Coherence or Frangibility.

Sect. 225.—This is the *fifteenth particular generic character*, and the third of those which are discovered *by the touch*. By *frangibility* is understood the greater or smaller degree of force requisite for separation. That this does not merely depend on its hardness may be immediately inferred from this—that, notwithstanding quartz is hard and hornblende

soft, yet the latter is much more difficultly frangible than the former. Generally speaking, all malleable minerals are difficultly frangible, and those possessing a foliated or conchoidal fracture more easily frangible. The different degrees of frangibility, which do not admit of a fuller explanation, are denoted by the five following distinctions: viz. *very difficultly frangible*, as native metals, massive common hornblende, and basalt; *difficultly frangible*, as quartz and asbestus; *rather easily frangible*, as martial pyrites and vitreous copper ore; *easily frangible*, as galena, opal, and baroselenite; and *very easily frangible*, as pit-coal and amber.

The Flexibility.

SECT. 226.—Solid minerals are further distinguished from each other in this respect, that some are capable of being bent, and that others, on the contrary, break. The former are called *flexible*, the latter *inflexible;* and the character is in general called the *flexibility;* being the *sixteenth particular generic character*, and the fourth of those which are discoverable *by the touch.* Few minerals occur flexible, and these are distinguished into *common* and *elastic.* Common flexible minerals are those which remain in the direction in which they have been bent, and of this kind are all perfectly malleable minerals, the fibres of amianthus, and talc in thin tables: elastic flexible are those which return to their former position on the power which bent them being discontinued; as mica, and elastic mineral pitch from Derbyshire.

The Adhesion to the Tongue.

SECT. 227.—In applying solid minerals to the tongue, or the lips, we find that some imbibe the moisture and adhere, and that others do not. This is called *adhesion to the tongue*, being the last *particular generic character* discoverable *by the touch*, and the *seventeenth* in the general arrangement. It

is very characteristic of those few minerals to which it appertains, which are very soft, soft, and half-hard. Lithomarge and fullers'-earth are thus distinguished from each other. Minerals either *adhere strongly*, as hydrophane; *rather strongly*, as bole and lithomarge; *weakly*, as talc; *very weakly*, as clay; or *not at all*.

The Sound.

Sect. 228.—This is the *eighteenth* and *last particular generic character*, and the only one observed in them *by the ear*. *Sound* is distinguished into *ringing* or *resounding*, *creaking*, and *rustling*. Some few, when suspended and struck with a hard substance, *ring* or *resound*. Ex. Native arsenic, long rock-crystals, thin slabs of specular gypsum and slate; also the columnar distinct concretions of argillaceous iron-stone from Hoschnitz. The *creaking* sound is heard most distinctly in natural amalgam when pressed with the finger; hence it is a character appertaining in some measure to the touch. The same sound is heard in cutting brittle minerals. Lastly, *rustling* is the dullest kind of sound, and heard in handling a mineral, or in passing the finger over its surface; as in mountain cork and farinaceous zeolite.

II. Particular Generic Characters.

Of Friable Minerals.

Sect. 229.—*Friable minerals* consist of a number of minute aggregations, which do not cohere at all together, or so slightly that the whole may be reduced to powder by the bare pressure of the finger. The greater part of earthy minerals are friable, the remainder are solid.

As friable minerals are deficient in many characters, as fracture, form of the fragments, transparency, streak, hardness, solidity, flexibility, and sound, and possess others not occurring in solid minerals, I have brought them under one particular head, though in other respects they belong to the latter class.

Sect. 230.—Among the particular generic character of friable minerals, those which the eye observes appear first; as *external form*, *lustre*, *appearance of the particles*, and *stain*: then follows that character which is observed by the touch, which is *friability*.

Sect. 231.—*The external form.* The *external form* of friable minerals is either *massive; interspersed;* as, a *thick* or *thin overcast* or *investure*, as black copper ore and earthy red cobalt ore; *spumiform*, as red and brown scaly iron ores; *dendridic*, as brown scaly iron ore, earthy grey ore of manganese; or *reniform*, as pure argil and earthy talc.

Sect. 232.—*The lustre.* I have already mentioned *lustre* generally in Sects. 173 and 180, and how it should be determined. I will here, therefore, only observe, that friable minerals are never found with any strong degree of lustre, but either *glimmering* (*common* or *metallic*), or *dull.* We have *glimmering* scaly iron ore, earthy talc; sometimes also friable ore of manganese; and *dull*, earthy lead ores, lithomarge, calcareous and argillaceous earths. Friable minerals are most commonly dull.

Sect. 233.—*The appearance of the particles.* The particles of friable minerals, when observed by the eye, appear as dust (*dusty*), or very small scales (*scaly*). This is the *third particular generic character* of friable minerals, and is called the *appearance of the particles.* Scaly particles are found in scaly iron ore and earthy talc; dusty particles are met with in black copper ore, iron ochres, earthy lead ores, lithomarge, and others.

Sect. 234.—*The stain.* I have already described the *stain* in Sect. 216. I will here only observe, that all friable minerals stain in different degrees; thus, scaly iron ores stain much more than black copper ore and earthy lead ores.

Sect. 235.—*The friability.* Is the *fifth* and *last particular generic character* of friable minerals, and the only one which we discover *by the touch.* By the *friability* is understood the different degrees of coherence of the small component parts. They occur *pulverulent;* or they cohere

slightly together, and they are said to be *loosely-coherent:* the latter border on solid minerals.

III. Particular Generic Characters.

Of Fluid Minerals.

Sect. 236.—*Fluid minerals* are those whose integrant particles cohere and move among one another, so that, space being given, they flow by means of their own gravity.

The few particular generic characters observable in this class are, *external form, lustre, transparency, fluidity,* and *wetting the fingers.*

Sect. 237.—*The external form.* The *external form* of fluid minerals is the *first particular generic character* observable *by the sight.* It scarcely occurs in any besides native quicksilver, which is found *in globules* and *liquiform.*

Sect. 238.—*The lustre* is the *second particular generic character* discoverable *by the sight.* With respect to the explication of this character I refer my readers to Sects. 173 and 180, and will only observe that the lower degrees of lustre do not occur in fluid minerals, all being *shining* (*common* or *metallic*). The latter occurs only in native quicksilver.

Sect. 239.—*The transparency* is the *third particular generic character* observable *by the sight.* As *transparency* has been already described in Sects. 209 and 214, I will here only observe that fluid minerals do not require so many degrees to determine the transparency. The following are sufficient: *transparent,* as in naphtha; *turbid* (comprising all intermediate degrees), as in petroleum; and *opaque,* as in native quicksilver.

Sect. 240.—*The fluidity* is discoverable *by the touch;* thus we find that the molecules of some are more easily moveable (one among another) than of others. Some are *perfectly fluid,* others *cohesive.* Cohesive forms the transition into malleable. Most fluid minerals are perfectly fluid; none beside petroleum is cohesive.

SECT. 241.—*The wetting of the fingers* is the *fifth* and *last particular generic character*, and the second of those discovered *by the touch*. Some *wet* the fingers, as in the case of petroleum; others *do not wet* the fingers, as native quicksilver.

REMAINING COMMON GENERIC EXTERNAL CHARACTERS.

SECT. 242.—Having fully treated of *colour*, *cohesion of the particles*, with the *particular generic characters* of *solid*, *friable*, and *fluid minerals*, characters which occupy so wide a field, and require so detailed an exposition, we now pass on to the *remaining common generic characters*.

III. THE UNCTUOSITY.

Unctuous minerals are either *greasy* or *meagre*. The greasiness of minerals, at least of those which are solid or friable, may possibly proceed from a certain foliated or scaly shape of their smallest aggregated parts, and from the slight degree of coherence existing between these parts. In relation to unctuosity they are,—

1. *Rather greasy*—as pipe-clay;
2. *Greasy*—as fullers'-earth, and steatite;
3. *Very greasy*—talc, and plumbago.

Most ores, all salts, calcareous stones, gypsum, fluors, and a great many others, are meagre. The lustre which some minerals acquire by the streak, as earthy cobalt ores, may also be considered as a certain degree of unctuosity.

IV. THE COLDNESS.

SECT. 243.—Is the *fourth common generic character* indicating the sensation of different degrees of cold. The chief cause of coldness seems to be hardness and density; for we may generally observe, that the harder and heavier a mineral, the colder it feels. Thus the diamond feels colder than marble, marble colder than alabaster, alabaster colder than chalk.

Minerals are — 1. *Cold*, as quartz, hornstone jasper, marble, and many others; 2. *Rather cold*, as serpentine, gypsum, steatites; 3. *Slightly cold*, amber, chalk, pit-coal.

The coldness serves in particular to distinguish stones to be cut and polished, not admitting an examination of such characters as fracture, hardness; and natural gems, which may thus be distinguished from such as are artificial.

V. The Weight.

Sect. 244.—Is the *fifth common generic character*, and the last of those observed *by the touch*. Colour may be perceived at a distance; cohesion of particles, unctuosity, coldness, by approaching nearer and feeling it; but the weight of a mineral is then only found when it is lifted by the hand.

Sect. 245.—As weight is in general determined by weighing in scales, and sight is necessary in this determination, some have reckoned it among those external characters which are discovered by sight. We have however, only to remark, that properly all external characters are perceived directly through the senses, occasionally assisted by means of instruments; thus, in the case of our senses being unassisted, weight must be perceived by the touch, and not by the sight.

Sect. 246.—The weight (or gravity) of a body is the property of attraction toward the centre of the earth, with a force proportionate to its mass.

It might be objected that this should properly be ranked among physical characters. To this I answer, it is true that weight does not immediately strike the senses; but many other external characters coincide with it in this respect, as colour and lustre, which are both perceived by means of the rays of light: but as weight may be perceived by *feeling* alone, independently of all other aid, we are fully justified in classing it among the *external characters*, *i.e.* among those which are discovered solely through the means of our senses.

Sect. 247.—The gravity of a body is determined either by examining its quantity in any certain volume of a body which may occur, which is properly called its *absolute weight;* or by observing the relation which it bears in this respect to another body of an equal volume, which is called its *specific gravity.* It is this latter, viz. the specific gravity, which we here consider as an *external character;* for it is invariable, whereas weight varies with the volume.

Sect. 248.—As specific gravity is determinate, it evinces a difference in constitution. For as it will never, or at least very rarely, happen that minerals shall be found of different constitutions possessing equal quantities of matter in equal volumes,—*i.e.* shall be of the same specific gravity—we may also conversely conclude in general that minerals of different specific gravities possess a difference in their constitution. Hence some are found which, though they nearly agree in their other external characters, are yet easily distinguished from each other by means of the difference in their specific gravities; as, *e.g.* Sulphurated bismuth from foliated lead-grey antimonial ore, and many others.

Sect. 249.—This external character cannot always be observed. If a mineral occurs *quite pure* (*i.e.* unmixed with any other), its specific gravity can be accurately determined; but this does not always happen, mixed specimens being frequently found. Here it is necessary to form a judgment of the specific gravity of the associated mineral, and thence to infer the specific gravity of the other; this, however, requires an experienced observer, and, even then, cannot be absolutely determined. Specimens sometimes also occur in which the mineral, whose specific gravity is to be examined, lies much dispersed and concealed, or perhaps a small portion only is mixed with a large portion of other minerals: in such this *external character* cannot be discovered.

Sect. 250.—In determining the specific gravity of a body it is compared with water, according to the usual method, and the difference of an equal volume of each remarked. To effect this most accurately the weight of water is divided into 1000 parts (though often into smaller decimal parts),

and the specific gravity of the body to be examined is then determined by the number of such parts. The experiment is made in several ways; but the most usual is that of weighing the body in pure distilled water.

A more detailed account of this, and other modes of examining the specific gravities of bodies, may be met with in all elementary treatises of natural philosophy.

In the Postscript to Chapman's "Brief Description of the Characters of Minerals," there is a description of an instrument for taking specific gravities, to which we refer our readers.—*Wern. Club.*

Sect. 251.—But this, as well as every other experiment employed by natural philosophers in the discovery of the specific gravities of bodies, is useless without apparatus. We must, therefore, use our senses, and when we examine this character in a mineral, by lifting it with the hand, our own feeling must tell us the relation which weight bears to volume; the latter is to be estimated by the eye.

Sect. 252.—The different specific gravities of minerals may be determined by comparison with water, as described in Sect. 250; it is, however, extremely inconvenient, and even almost impossible, to retain in the memory the specific gravity determined in this manner. As the determination need not be so very exact, and cannot be made accurately by the mere touch, I have assumed *five degrees* of ordinary comparison. Of each of these I have not only mentioned the relation to the weight of pure water, but I have also illustrated it by examples.

Sect. 253.—These degrees of specific gravity are—*supernatant*, *light*, *rather heavy*, *heavy*, and *extremely heavy*.

1. *Supernatant* minerals possess a less specific gravity than water, and hence swim on it. Ex. Naphtha, petroleum, mountain-cork, agaric mineral, and brown scaly iron ore.

2. *Light*—when the specific gravity (taking that of water at 1000 parts) varies between 1000 and 2000. Ex. All inflammable minerals.

3. *Rather heavy*—when the specific gravity varies between 2000 and 4000. Ex. Most earthy minerals.

4. *Heavy*—when the specific gravity varies from 4000 to 6000. This degree of specific gravity occurs chiefly among ores.

5. *Extremely heavy*—when the specific gravity exceeds 6000. Ex. All native metals. This and the former degree are frequently comprehended under the name of the metallic weight.

SECT. 254.—To determine the specific gravity, we need only mention the degree to which it belongs; but if it is to be rendered still more exact, its relation in this respect to another mineral of the same degree may also be determined, as *e.g.* green-lead ore is *heavy*, and heavier than vitreous copper ore, and lighter than vitreous silver ore. This is sufficient to distinguish any mineral with respect to its weight. If an accurate determination of specific gravity be thought necessary, it may be accomplished by following the method mentioned in Sect. 250.

VI. THE SMELL.

SECT. 255.—This is the *sixth common generic character*, and although of little importance as a general character, occurring only in a few species, is yet a very essential characteristic.

The smell is observed—either,

1. *Of itself*, without any addition; it which case it is

(*a*) *Bituminous*, as mineral-pitch, petroleum, naphtha.

(*b*) *Slightly sulphureous*, as in natural sulphur, grey antimonial ore—or

(*c*) *Bitter*, as in ochre.

(*d*) *Clayey*, as yellow chalk.

2. *After breathing on it* strongly and quickly. Hornblende and sienite, when breathed upon, smell *clayey bitter*.

3. *After rubbing or striking*, as,—

(*a*) *Urinous*, in swinestone after rubbing.

(*b*) *Sulphureous*, in pyrites.

(*c*) *Garlic*, arsenical pyrites, and white cobalt ore.

(*d*) *Empyrematic*, pit-coal, quartz.

VII. The Taste.

Sect. 256.—This is the *seventh* and *last common generic character*, and peculiar to one class only—salts. It is

(*a*) *Sweetish saline*, as the taste of rock-salt.

(*b*) *Sweetish astringent*, as natural alum.

(*c*) *Sourish astringent*, as native vitriol.

(*d*) *Bitter saline*, natural Epsom salt.

(*e*) *Cooling saline*, natural nitre.

(*f*) *Lixivious*, natural alkali.

(*g*) *Urinous*, natural sal ammoniac.

The different kinds of taste and smell can only be learned by experiment; and caution is necessary in examining those which might prove injurious to health; as quicksilver, copper, lead, and arsenic.

Conclusion of the Chapter.

Sect. 257.—These are the *external characters* necessary for distinguishing minerals. In *specific characters* and *varieties*, additions may possibly be found necessary, but the *generic characters* are complete. A description may occur which is not sufficiently clear; this deficiency, however, is fully supplied by the examples which are adduced.

As a perfect knowledge of these external characters (which, in fact, comprehends much more than many mineralogists are willing to allow) cannot be acquired otherwise than by attentive observation and continued practice, it would be very useful if mineralogists would form collections of minerals to be arranged according to this system of external characters.[1] Not only could the different specific

[1] This has been accomplished in the Leskean Cabinet of Fossils (now in the possession of the Dublin Society), in that of Pabst van Ohain, and in those of most mineralogical schools formed on the plan of the Wernerian.—*Trans.*

characters and varieties of the former be immediately identified, but minerals might be compared with each other in order to obtain perfect conceptions of their characters.

Chapter V.

Of the External Descriptions of Fossils.

Sect. 258.— External description is nothing more than the expression by words of the external conception which we have of a mineral.

If the external conception be *complete*, and *intelligibly* expressed in the *proper order*, the description will be *perfect*.

Hence, the *perfection* of the external descriptions depends in the observance of the following three general rules :—

Sect. 259.—*First General Rule.*— Every external description of a mineral should include all the external characters discoverable in it, and these accurately defined.

Sect. 260.—*Second General Rule.*—The external characters appertaining to an external description should follow each other in systematic order, *i.e.* in their natural order.

Sect. 261.— *Third General Rule.*—Every external character should be suitably expressed in the description by an appropriate and determinate denomination.

Sect. 262.—In order to contract the external descriptions, those external characters may be omitted which are negative, viz. the *form* of the *distinct concretions*, *transparency*, *stain*, *streak*, *flexibility*, *adhesion* to the *tongue*, *sound*, *unctuosity*, *smell*, and *taste*. These may be omitted when only negative.

Sect. 263.—It is also useful in external descriptions to print the principal characters larger, in order to excite the particular attention of the reader. Principal characters are those by which a mineral is distinguished from others to which it bears the greatest resemblance, as, *e.g.* in grey-silver ore, the *colour*, *lustre*, *fracture*, and *hardness ;* in specular

iron ore, the *colour*, *streak*, and *hardness;* in tinstone crystals, the *streak*, *hardness*, and *weight;* in martial pyrites, the *colour*, and *hardness;* in flint, the *lustre*, *fracture*, and *transparency;* in molybdena the *colour*, *fracture*, *stain*, and *unctuosity;* in swinestone, the *colour* and *smell;* in baroselenite, the *hardness*, and *weight*.

Sect. 264.—I now proceed to give some examples which will tend to illustrate what I have said respecting the construction of external descriptions.

Grey Copper.—H = 3.0 – 4.0; Sp. Gr. = 4.4 – 5.2; C, steel-grey; brittle; L, metallic; occurs massive, interspersed, specular, and crystallised (here state the various forms, which is best done by reference to plates); P F, tetrahedron and octahedron; weakly-shining, internally; fracture, uneven; breaks into indeterminately angular or moderately sharp-edged fragments; yields a black streak.

Green-lead Ore (Phosphate of Lead).—H = 3·5 – 4·0; Sp. Gr. = 6.9 – 7.1; C, green, yellow, grey, brown; occurs massive, reniform, and crystallised (here state forms); P F, the regular six-sided prism; L, greasy; fracture compact, approaching to conchoidal.

Red-lead Ore (Chromate of Lead).—H = 2.5; Sp. Gr. = 5.9 – 6.1; C, hyacinth red; brittle; occurs in flakes and crystals (here state forms); P F, an oblique rhombic prism; Stk. orange yellow; L, common; externally, shining or resplendent; F, uneven, passing into conchoidal.

Mica.—H = 1.5 – 2.5, but the edges of the laminæ scratch glass; Sp. Gr. = 2.7 – 3.0; structure, broad foliated, and foliæ elastic; occurs massive, interspersed, and crystallised in equiangular hexagonal tables and perfect hexahedral prisms; brittle; fragments tabular.

Common Talc.—H = 1.0 – 1.5; Sp. Gr. = 2.6 – 2.8; C, white, or greenish white, very unctuous to the touch; occurs massive (with foliated structure), and crystallised in small six-sided tables; L, mother-of-pearl; F, foliated; fragments, tabular.

Specular Gypsum.—H = 3.0 – 3.5; Sp. Gr. = 2.6 – 3.0;

C, white, or reddish white; occurs massive, contorted, lamellar, granular, fibrous (in stelliform concretions), and crystallised in equiangular hexahedral prisms, and in twin-crystals; P F, right-rectangular prism; L, glassy; fracture, straight, curved, or foliated; fragments, rhomboidal; transparent; brittle; meagre to the touch.

Vitreous Silver Ore — Copper Ore — Tinstone — Copper Pyrites — Arsenical Pyrites — Tin Pyrites are described in Weaver's "Translation," as further illustrations; but we conceive that the subject has been amply illustrated in the foregoing minerals, which we have only inserted for the purpose of giving the modern system of description.

Sect. 265.—A few words remain to be said respecting the *chemical*, *physical*, and *empirical* characters. These characters, though not universal, often render essential service.

Sect. 266. — Among *chemical* characters, experiments with acids are the most simple. *Nitric acid* is used to test effervescence; as fibrous and compact malachite, azure copper ore, white and black-lead ores, earthy lead ores, calcareous spar, &c. *Volatile alkali* is employed to test copper, by observing whether it dissolves the mineral and imparts a blue colour. *Distilled vinegar* is applied as a test of lead, by digesting the mineral in it for a short time, and observing with caution if it communicates a sweetish taste.

Some minerals are volatilised by heat, as orpiment, natural sulphur; others change colour, and others melt easily, as grey antimonial ore, and native bismuth. Cinnabar burns with a brown flame, and pit-coal, bituminous shale, natural sulphur, and mineral pitch, are combustible.

Qualitative analysis, ascertained by the action of acids and the blow-pipe, is an important aid to the mineralogist, but is beyond the reach of most students. The effects produced on minerals by the action of acids, are effervescence, solubility, gelatinising; these characters are observed by reducing the mineral to powder and diluting the powder in a test-tube, either simply or by the action of heat. The acids most commonly employed are *nitric*, *muriatic*, and *sulphuric* acids.

The blow-pipe is an important help, used with *re-agents*, such as the following:—*carb. soda*, *borax*, *phosph. soda* or *ammonia* (*microcosmic*

salt), *bisulphate of potash*, *nitrate of cobalt*, *saltpetre*, *silica*, *oxide of copper*, *bone-ashes and refined lead; litmus, turmeric, and Brazil-wood test-papers*, *fluor spar*, *and dried gypsum*.

A brief, but very useful account of the processes of the blow-pipe analysis may be found in Chapman's "Brief Description," to which frequent reference has been made in our notes; especially in the Appendix of that work (*i.e.* from p. 61).—*Wern. Club.*

SECT. 267.—Among *physical* characters we may observe, by rubbing, whether light substances are attracted, such as bits of paper; Ex. amber, hyacinth, and others. Further, some iron ores are magnetic; as magnetic iron-stone, magnetic pyrites, magnetic iron-sand. Some minerals are phosphorescent when strongly rubbed, as some blende; or when heated, as fluor, which is slightly phosphorescent.

Lemnian and Striegau bole, when thrown into water, split into pieces with a crackling noise; and some opals become more transparent by immersion in water.

Electricity is of two kinds, *positive* and *negative*, and may be produced in some minerals by heat or friction, in the manner described; the quality of the electricity may be determined by an insulated electrometer: crystallised minerals, as tourmaline, topaz, boracite, generally possess different kinds of electricity on their extremities or opposite planes.

Magnetism is an important, though limited character, and may be detected by a small magnetic needle; the only metals which attract the magnet are iron, nickel, and cobalt. All minerals which attract the magnet act equally on both poles, except magnetic oxide of iron, which attracts one pole and repels the other; this property is termed "polarity."

Phosphorescence is the emission of a faint light, by heat or friction. Two pieces of quartz, some varieties of zinc-blende or calc spar, rubbed together, present a luminous appearance on the rubbed surface. Minerals which become phosphorescent by heat, almost invariably contain either *fluorine*, *chlorine*, *phosphoric acid*, *boracic acid*, strontia, lime, or zinc. Phosphorescence is intimately connected with the emission of coloured flames in blowpipe analysis.—*Wern. Club.*

SECT. 268.—Of *empirical* characters, efflorescence is peculiar to some ores; which in copper ores is green or blue; in iron ores, generally brown, yellow, or red; in cobalt, peach-blossom red; in arsenic, white.

Again, some minerals are associated with others; as,

nickel with cobalt, arsenic with orpiment; grey copper with copper pyrites and grey silver ore, purple copper ore with copper pyrites, grey silver with galena, red copper with native copper. White cobalt is rarely found without nickel, which distinguishes it from arsenical pyrites.

This subject is found, most at large, in a work entitled "A System of Mineralogy, in which Minerals are arranged according to the Natural History Method," by *Robert Jameson*. Edinburgh. 3 vols. 8vo.—*Wern. Club*.

FINIS.

London:—Printed by G. BARCLAY, Castle St. Leicester Sq.

PURSUANT to a Resolution to the following effect, passed at a meeting of the Committee, held on Wednesday, November 13, 1850 :—

" The best thanks of the Club are hereby presented to—

The Rev. CHARLES MOXON, LL.B., *the Superintending Editor and Translator of this Work.*

And to—

Professor CHAPMAN, *of University College, London.*
ARTHUR DEAN, Esq. C.E.

For the Editorial Assistance rendered by them in the preparation of the accompanying Work."

AN ANALYSIS

OF

THE NATURAL SYSTEM

AND ITS

APPLICATION

TO THE

MINERAL KINGDOM.

AN ORIGINAL ESSAY.

Edited by the Wernerian Club.

PRINTED FOR THE CLUB

BY

GEORGE BARCLAY, CASTLE STREET, LEICESTER SQUARE.

1846–47.

PURSUANT to a resolution to the following effect, passed at a meeting of the Committee held on March 25th, 1846,

> "The best thanks of the Club are hereby presented to James Edward Moxon, T. W. Barlow, Jonathan Couch (in the department of Zoology, &c.), P. N. Brockedon, E. J. Chapman, and Charles Moxon, Esquires (in the department of Mineralogy), for the editorial assistance rendered by them in the preparation of the accompanying work."

AN ANALYSIS

OF

THE NATURAL SYSTEM

AND ITS

APPLICATION TO THE MINERAL KINGDOM.

INTRODUCTION.

"Natural History has generally been termed a science of observation, and such, in a restricted sense, it undoubtedly is. The error of the definition is this:—not that it is untrue, but that it is partial and insufficient. All branches of natural science, however varied may be their materials, or however diversified their nature, have but one and the same object in view—the discovery of the primary laws of nature. In comparison with this, all other objects, however superior they may be in point of utility, yet, in reference to sound philosophy, are of a secondary and subordinate nature. As all sciences are based upon facts, known, or to be known, from experience, so are they, in their early state of developement, matters of pure observation. It is only when we have acquired the power of generalising these facts, when such generalisations agree among themselves and with every [illegible] we see and know of nature, that the theory of a

science becomes either absolutely demonstrative, or approaches so near to certainty by the force of analogical reasoning, that it is not contradicted by any thing known. The case of Natural History, then, is precisely this: in its early stages it is a science of observation; in its latter, it is one of demonstration. There are few, indeed, that have the least suspicion that Natural History is deserving of this character. But the question resolves itself into this: — Are there any fixed and universal laws by which the variations of the forms of Nature are regulated? If this question can be answered in the affirmative, if all these variations can be traced to certain primary types, following each other in one constant, definite series, we have the most conclusive evidence that human research can elicit. That such is the case, the facts herein contained will sufficiently testify, and which coming within the range of observation, it will be in the power of every one to verify or disprove." *

"It may be objected that such principles as these, involving, as they do, the doctrine of final causes, suppose us to be acquainted with the intentions of the Creator, which, it has been insinuated, is a most presumptuous and irrational basis for our reasonings. But there can be nothing presumptuous or irrational in reasoning on that basis, which, if we reject, we cannot reason at all. If we really can discern and cannot help discerning a design in the Works of the Creation, this principle is the soundest and the most satisfactory ground for the convictions to which it leads. The ideas which we necessarily employ, in the contemplation of the world around us, afford us the only *natural* means of forming any conception of the Creator and Governor of the universe; and if we are by such means enabled to elevate our thoughts, however inadequately, towards Him, where is the presumption of doing so? or rather, where is the wisdom of refusing to open our minds to contemplations so animating and elevating, and yet so entirely convincing? The assertion appears to be quite unfounded, that, as science

* Swainson's "Preliminary Discourse," p. 104.

advances from point to point, final causes recede before it and disappear one after another. We are rather, by the discovery of the general laws of nature, led into a scene of wider design, of deeper contrivance, of more comprehensive adjustments. Final causes, if they appear driven further from us by such an extension of our views, embrace us only with a vaster and more majestic circuit; instead of a few threads connecting some detached objects, they become a stupendous network, which is wound round and round the universal frame of things."*

* Rev. Wm. Whewell's "Philosophy of the Inductive Sciences," vol. ii. p. 92.

PRINCIPIA.

"O Jehova!
Quam ampla sunt Tua Opera;
Quam sapienter Ea fecisti;
Quam plena est Terra possessione Tua!"
LINNÆUS.

OF THE OBJECTS OF NATURAL SCIENCE, AND THE MEANS FOR ITS PROSECUTION.

(1.) THE chief object of all natural science is the illustration of that unity and harmony of plan, visible through the whole of creation, by which we are enabled to observe the wisdom and goodness of GOD, as manifested in his works.*

(2.) The means for effecting this object are:—1. By our endeavouring to become acquainted with the structure, economy, and relationships of the animals, plants, and minerals, existing upon the earth; and 2. By endeavouring to determine the station or rank which each individual holds in the system of nature.†

* Independently, moreover, of the high intellectual gratifications which the study of nature presents, an equal inducement will be found for its prosecution, if it be considered only as an auxiliary to our worldly comforts and luxuries. "The zoologist," for instance, "is instructed to what species of the animal part of the creation we are most indebted for assistance and security, which of them, while living, aid us most in our enjoyment and necessities, and which, when dead, contribute their share to our food and raiment."—*Wern. Club.*

† (2.) "The three departments of study here brought forward, as pursued by the practical and the scientific naturalist, may be combined

(3.) But as the powers of the human mind are limited, we are obliged to be satisfied with a *general* knowledge of the *whole* system of nature, in order that we may devote our energies more exclusively to the investigation of some particular department.

(4.) Method or arrangement condenses and facilitates this knowledge, and is therefore essential to its acquirement. By means of a *system of arrangement* we are enabled to gain, not only a more ready acquaintance with an individual species, but also general ideas concerning the groups, of which a species forms but a part.*

in moderation without detriment. The student may observe in the fields, and study in his closet; and this is usually done by all the rising naturalists of the present day."—*Wern. Club.*

* "Systems or arrangements are of two kinds, natural and artificial."

"An artificial system has for its object simple classification, and should afford every facility for the ready discrimination of species. Affinities are only a secondary consideration. The most admirable classification of this description ever invented is the Linnæan System of Plants, termed the Sexual System."

"A natural system, on the contrary, to be in accordance with the name it bears, should endeavour to point out the various affinities of species in all their complex relations; in addition to furnishing, as the other also does, particulars connected with their structure and economy." — Swainson.

M. Jourdan, a French naturalist of eminence, advocates the arrangement of the animal kingdom according to the developement of the *nervous system*, and considers that "animals should be classed according to their respective degrees of animation and sensibility; the circulation of the blood, respiration, digestion, and generation," not seeming to him, "to correspond with the degrees which may be measured by means of the above-mentioned faculties. The nervous system, on the other hand, is always developed in proportion to the sensibility," and on this he takes his stand. "The more abundantly animation is exhibited the more extensive does the nervous synthesis appear. The fly, for instance, is more animated than the oyster; and thus the advocate of a single series of beings would see assigned to the articulata that pre-eminence over the mollusca which was denied to them by Cuvier. Just as vegetables and minerals have their sovereign characteristic law, so animals have theirs in *animation*, which shews itself by means of the sensations producible, in successive degrees, from the lowest insect up to man, who combining

OF THE NATURAL SYSTEM (*SYSTEMA NATURÆ*).

(5.) Of natural systems, there can be but *one*, and that one must be the system or plan of the creation. This, to be in accordance with the CREATOR's attributes, includes universality, order, and harmony.*

them all raises them to a yet more elevated point; so that man," according to Jourdan, "is an *animal microcosm*." This proposition of M. Jourdan is perhaps more ingenious than sound. It has, nevertheless, strong claims on the consideration of scientific zoologists.

* "The variety in nature appears infinite. If we only contemplate those beings which have passed under our observation, and which every where surround us, we cannot fail to be struck with that Divine skill, which could imagine and produce such a wonderful diversity of forms. It is obvious therefore that these, as emanating from a Divine Creator, must have been produced upon some one uniform, harmonious plan. Hence it follows that no system can be *natural* which does not aim at the developement of this plan, so far, indeed, as its comprehension is permitted to finite beings."— SWAINSON.

In the fact of the utter inutility of artificial systems of arrangement naturalists of the present day unanimously coincide; for however subtle and ingenious in construction, it seems impossible that any such can stand the test of experience.

The difficulties attending the formation of a natural system are evident. In zoology (and the remark is equally applicable to the other kingdoms of nature) it is impossible that such an one can ever be rendered complete until *every* living creature inhabiting the globe shall be known to us. It must also be founded, not upon the "adaptive," but upon the "essential" characters by which the different classes of animals are distinguished. By the *essential* characters is meant such as discharge or assist in discharging some or other of the more important vital functions, such as respiration, circulation, &c.; by the *adaptive*, such external characters as fit the creature for some particular mode of life. It is obvious, therefore, that upon the comparative anatomist must devolve, in a great measure, the task of collecting the materials necessary to the formation of such a system; and we may fairly presume that further research and discovery will furnish us with connecting links between those groups of living creatures which we are already enabled to arrange in an order agreeable to the supposed system of nature, and others which at present have an apparently isolated position. The great principle of the natural system cannot be better described than in the words of M. Duval-Jouve, viz. "To place organised beings in such order, that any one of them,

(6.) The idea that a simple series, aptly termed "the chain of being," was the plan of the Creation, has long been found to be without foundation by all who have put it to the test of examination—all natural affinities have, on the contrary, been found to approach the circular, that is, are disposed in a circular manner; and the circles thus formed, to depend, as far as is yet known, upon the laws of affinity, of analogical representation, and of variation.

(7.) These laws are believed to constitute the first principles of the science,* and are as follows:—†

(*Swainson's Works*, ii. p. 224.)

I. "That every natural series of beings, in its progress from a given point, either actually returns, or evinces a tendency to return, again to that point, thereby forming a circle (or group)."

II. "The primary circular divisions of every group are three actually, or five apparently.

III. "The contents of such a circular group are symbolically (or analogically) represented by the contents of all other circles in the animal kingdom."

(Whence it follows):—

IV. "That these primary divisions of every group are characterised by definite peculiarities of form, structure, or economy, which, under diversified modifications, are uniform throughout the animal kingdom, and are therefore to be regarded as the primary types of nature."

selected at random, shall have a greater relationship with its neighbours than with any other species; or, in other words, to assign to each species that place which it really occupies in nature, and in which its propinquity to or distance from every other species shall exactly correspond with the amount of difference between it and each of them."—*Wern. Club.*

* But some of them are not so unexceptionably true as others.

† Although these principles have, at present, been chiefly applied to the animal kingdom only, nevertheless there is every reason to believe that they are the same throughout the whole of the three kingdoms of nature, and therefore apply equally to all. (*Vide* Sequel.)

V. "That the different ranks or degrees of circular groups exhibited in the animal kingdom are nine in number, each being involved within the other."

SYSTEM OF AFFINITIES.

"*That every natural series of beings in its progress from a given point, either actually returns, or evinces a tendency to return, again to that point, thereby forming a circle (or group).*"

(1.) This, the first principle of the natural system, is that upon which all the others repose, and has already been demonstrated in almost every department of zoology and botany.

(2.) *Circles of affinity* are of two kinds, perfect and imperfect.

(3.) A perfect circle of affinity (or group) is formed when no link in the chain of its continuity appears wanting.

(4.) An imperfect group is, on the contrary, one in which a portion or portions of the series of affinities may not be apparent.

(5.) This imperfection may arise from two causes: first, either these absent links remain undiscovered, or, secondly, they have been destroyed in the revolutions which have agitated our globe.*

(6.) *Natural affinities* are likewise of two kinds:— 1. Simple or internal affinities; and 2. External affinities.

(7.) Simple or internal affinities are two in number, and may be defined as those by which an object is connected with that which precedes and with that which follows it.

(8.) External affinities may be defined as the means by

* "For example, the order pachydermata, in the class mammalia, includes a small number of animals,—the elephant, rhinoceros, tapir, hippopotamus, &c.—which stand completely apart, as it were, from each other, not being connected by intermediate forms. They are, however in reality, connected most closely by fossil species, which present the most remarkable and interesting combinations of characters that are now found separately in the forms with which we are familiar."— *Wern. Club.*

which one object is connected with another placed in a different circle.

(9.) Every object in nature possesses these three relations of affinity.

(10.) Simple affinities must exist under any system of arrangement which notices the progression of nature.

(11.) External affinities, however, are not always so obvious as these latter, except in those aberrant groups which connect two different circles.

SYSTEM OF VARIATION.

"*The primary circular divisions of every group are three actually, or five apparently.*"

(12.) Every group,* whatever may be its rank or value, that is, its size or denomination, contains *three* other primary groups, whose affinities are also circular.

(13.) These are respectively denominated:—

I. Typical.
II. Sub-typical.
III. Aberrant.

(14.) The aberrant group, in consequence, probably, of the diversified nature of its contents, as influenced by the families to which by affinity it is connected, has been found to contain three other groups. In this group the external affinities (8) are in general the most strongly developed (11).

(15.) We consequently have, in every natural group, three primary circles of affinities, one of which (the aberrant) is divided into three secondary circles of affinities.

* Although man is connected with animals by reason of his material structure, yet he forms no part of *their* system of affinities, but is a being

SYSTEM OF ANALOGICAL REPRESENTATION.

"*The contents of such a circular group are symbolically (or analogically) represented by the contents of all other circles in the animal kingdom.*"

(16.) Every observer must perceive that each created being has different degrees or kinds of relationship or resemblance to others.

(17.) When this relationship is immediate it is termed an affinity (6); when remote, *a relation of analogy.*

(18.) Relations of analogy will therefore consist in a correspondence between certain insulated parts or properties of the organisation of two animals, which differ in general structure.

(19.) Analogies will be more or less apparent, according as the groups compared are of equal value, and approximate to each other in the general system.

(20.) Consequently they will be more or less faint and difficult to trace, according as the groups differ in value and are remote.

(21.) For which reasons, in speaking generally of analogies, we must always take into consideration the nature of the groups compared.

(22.) These relations of analogy, however, do not rest upon one or two indefinite particulars, which may be chosen according to our own will, nor are they irregular.

(23.) But the analogies existing between two groups (if the groups are natural), will occur in a definite succession, and all the parts of one circle will represent those of another (and therefore of all others).

(24.) "This is the system of analogical representation, which has been found to exist in nature, and no law of the natural system is more calculated to keep in check the ardour of imagination."

(25.) Another of its most important results is the clue

of a superior order, placed upon earth to undergo a state of trial.—*Wern. Club.*

that it affords to the location of types and to the determination of such chasms as occur in imperfect groups (4).*

(26.) If the divisions of one circle thus represent those of others, it will follow :—

"*That the primary divisions of every group are characterised by definite peculiarities of form, structure, or economy, which, under diversified modifications, are uniform throughout the animal kingdom, and are therefore to be regarded as the primary types of nature.*

(27.) The definite peculiarities of form, structure, and economy, as existing in each of these groups (13), may be thus concisely stated, by way of example :—

(*Abridged from Swainson's Classification of Animals.*)

1. *Typical Groups.*—Their chief distinction is implied by the name they bear; the objects they contain being the most perfectly organised; that is, endowed with the greatest number of perfections, and capable of performing to the greatest extent the functions which peculiarly characterise their respective circles.

"Perfection in the number of species and of forms is also a remarkable and very general character of *pre-eminently* typical groups."

2. *Sub-typical Groups*, as the name implies, are a degree lower in general organisation in regard to the

* The *details* of this subject seem at present to be involved in some perplexity; and, considering the comparatively short period that has yet elapsed since its discovery, this is not surprising. With regard to the definite peculiarities of these types (27), should not those of pre-eminently sub-typical circles, in addition to being the most completely organised of their respective circles, be also (amongst animals) the most rapacious? In which case the Raptores would stand as typical of the birds. The Endogens would then be the types of plants; and is this not the case? In conclusion, would not this principle of *definite variation* in the *location* of types hold good throughout all groups? It does not seem to interfere with the regularity of succession in which such types occur (23).—*Wern. Club.*

functions which particularly characterise their own typical group, and thus they take an intermediate station between typical and aberrant divisions.*

3. *Aberrant Groups.* — All groups of this kind are naturally divided (14) into three distinct types, which, collectively, form the aberrant circle of every group.†

* They do not comprise the largest individuals in bulk, but always those which are the most powerfully armed, either for inflicting injury on their own class, for exciting terror or creating annoyance to man. Amongst animals, their dispositions are often sanguinary, since the forms most conspicuous among them live by rapine, and subsist upon the blood of others. In regard to the numerical contents of these groups, they are almost universally less than those which are typical.—*Wern. Club.*

† These have been termed (on account of the analogies which they bear to other groups),—

The Aquatic or Natatorial,
The Suctorial,
The Rasorial.

The Aquatic or Natatorial Type (represented by the natatorial order of birds, &c.) as the name implies, are more especially inhabitants of the waters. They possess many and striking peculiarities, modified, indeed, in the most astonishing manner, but more conspicuous, perhaps, throughout all natural groups than any of those belonging to other types. *As to structure*, aquatic types are chiefly remarkable for their enormous bulk, the disproportionate size of their head, and the absence or minor developement of the feet. *As to their economy*, they may be designated as being almost exclusively carnivorous, and on account of the less perfect structure of their feet, they seize their food in most cases, but more especially in pre-eminently aquatic groups, by the mouth alone.

The Suctorial Type (represented by the grallatorial order of birds, &c.) is remarkable, for the objects it contains being most frequently small in size and the organs of mastication being less perfectly developed. We consequently find that animals of this type imbibe their food, in many instances, by suction, and it is also to be considered as the least perfect of it respective circle.

The Rasorial Type (so termed in ornithology) is the third and last which enters into the aberrant circle, which circle is always closed by the union of this type with the natatorial; hence it follows, that both approximate somewhat in their *general* characters. In size, the objects it contains are inferior to the natatorial, but in their economy they are widely different, being strictly terrestrial; and, in addition to this, they [illegible]remarkable for docility and sociality. How strikingly is this the case

(28.) It has already been shewn that the animal kingdom is composed of a number of circles of affinity (I.), touching and blending into each other at various points* (II.), and representing each other by innumerable analogies (III. IV.)

(29.) If we commence, for instance, with species, we find that they form a little circle of themselves, and that several

in the ungulata among quadrupeds, the rasores among birds, and the hymenoptera (bees) among insects, all of which are of this type. The duck, in a similar manner, forms the rasorial type of the natatores, and the dog that of the feræ. But in proportion as we recede from these animals, whose size, intelligence, and structure, render them fit companions or assistants to man; and, advance towards the lower, or invertebrated groups, this peculiar characterestic, although present, becomes fainter and fainter.

Thus, looking to the testaceous mollusca as the rasorial division of the animal kingdom, we find their services simply confined to supplying us with a wholesome and nutritious food;—for it is remarkable, that nearly the whole of the animals are edible, and form a main article of subsistence with most uncivilised nations.

Rasorial types are likewise remarkable for the frequent developement of ornamental appendages, whether in the form of tails, frontal appendages, crests, or otherwise.

(With regard to the above characters of the various types a few words in explanation are necessary. Thus, we cannot hope to find all these definite characters throughout every group. Upon such a principle, that beautiful and astonishing variety which constitutes one of the most remarkable features in the creation, would be destroyed, and if each type were to exhibit *all* the properties or peculiarities theoretically belonging to it, we should have but *five* unvaried forms of living beings. It is, therefore, only in such groups as are the *pre-eminent* representatives of these types that we can hope to find them strikingly developed: in all others they will only be present in a lesser degree, and must, therefore, be traced through *a number of intermediate analogical forms.*

" *That the different ranks or degrees of circular groups exhibited in the animal kingdom are nine in number, each being involved within the other.*"—*Wern. Club.*

* We not only find genera, families, orders, and classes, blending into each other as above described, but also the two grand organic kingdoms uniting insensibly together, by apparently intermediate links. Buffon was of opinion, that no exact line of division could be drawn between these kingdoms; and in the present day, we find Professor Rymer Jones expressing himself thus: " It has recently been stated, and apparently

of these little circles congregate, as it were, and unite into a larger one.

(30.) Others still succeed; every new combination being greater than that preceding it: small circles are absorbed in larger until all are embraced in *one*, composed of the animal kingdom.

(31.) It follows, therefore, that although all natural groups are circles, yet are these circles of different sizes, ranks, and value.

(32.) It consequently becomes necessary to designate these groups by particular names, in order that their comparative value may be understood.

(33.) The animal kingdom then (in so far as we are yet acquainted with its affinities) may be said to contain nine different ranks or gradations of *circular* groups, commencing with the highest and terminating with the lowest assemblages.

(34.) These groups have received the following names, expressive of their relative value; the sub-genus being the lowest description of circular group yet discovered:—

1. Kingdom.
2. Sub-kingdom.
3. Class.
4. Order.
5. Tribe.
6. Family.
7. Sub-family.
8. Genus.
9. Sub-genus.

upon good foundation, that there are organised forms that are vegetables at one period of their existence and animals at another: many of the *confervæ*, for example, are equally claimed by zoologists and botanists;" and he concludes by saying that, "so nearly do the animal and vegetable worlds approximate," and "so gradually and imperceptibly do their confines blend, that it is at present utterly out of the power of the physiologist to define exactly where vegetable existence ceases and animal life begins." Professor Jones augurs that microscopic examination of the tissues which enter into the composition of organised substances will do much towards the solution of the above difficulty.—*Warr. Club.*

(35.) Of other ranks, and which follow the latter of these, there are *two*; — species and varieties.*

(36.) *A species* may be considered as a *definite* natural object, whose differences from those most nearly related to it are, as far as observation has extended, permanent, and are, therefore, presumed to have had their origin in the creation. *Varieties* may be caused by an infinitude of minor or local circumstances, such as climate, food, or the intermixture of species.†

ON THE VERIFICATION OF GROUPS.

(37.) It follows from the preceding remarks that the verifications of a natural group are three: 1. The circular series of its contents (System of Affinity); 2. The parallel relations of its parts to other groups (System of Variation); and 3. The symbolical representation of the primary types of Nature (System of Analogical Representation).

(38.) (V.) There are no absolute rules of universal application, independent of analysis, which can be laid down for the discovery of a natural group. We must begin, in fact, by arranging the objects with the nicest attention to their apparent affinities and then testing the result.

(39.) If these affinities are real, and the group is natural,

* The true determination of *species* in the animal kingdom is a matter often beset with many difficulties, principally arising from the changes which take place in animals at particular seasons and under peculiar circumstances, from the great difference often existing between the two sexes of one species, and also from the complete metamorphosis, both in external and essential characters, occurring among some of them at different stages of their existence. The last peculiarity is principally met with in the class of insects, but some of the vertebrata are also liable to it. As an instance of the mistakes which have thus arisen, it may be mentioned, that, for a considerable time, the *zoea*, a small crustaceous animal, was considered as constituting a genus by itself, but has since been discovered to be nothing but the young of the common crab.—*Wern. Club.*

† It is, at the least, exceedingly doubtful whether any permanent variety has been caused by intermixture of species; for uniform observation tends to prove that mules leave no posterity.—*Wern. Club.*

there will be an evident tendency to a circle; and this tendency will be more or less strong in proportion to the number of objects which enter into the series.

(40.) But the relations of objects being complicated, and by no means confined to those which precede and those which follow them in circles of affinities, it is obvious that false circles may be formed, and, consequently, other tests are necessary.

(41.) Before these are proceeded with, it is absolutely necessary to make out the *external* affinities of the circle under investigation; that is, to discover by what means it is in connexion with such others as precede and follow it.

(42.) (II.) The second test to which our supposed circle must be brought, is that of proving those relations which its contents bear to the neighbouring circles and to all others in its own class or order; that is, to make its contents agree with those of others.

(43.) It may, indeed, happen from certain causes (4), that one, or even two, of its subdivisions are wanting, while in the group with which it is compared they are present. This leads us more immediately to another test, which is still, however, essential in all cases.

(44.) (III.) The system of representation, by which the types or divisions of a natural group are determined and proved, is this third and last test. By this we can judge whether our group is perfect or imperfect, and by this we can calculate from analogy the probable extent of the gaps that sometimes occur in a natural series.

(45.) And should the divisions of our circle upon comparison exhibit a conformity, however remote, whether in structure, habits, or economy, with those of other circles, and should they follow each other in the same progression, we may conclude that our series of affinities is probably natural.

ON THE CHARACTERS OF GROUPS.

(46.) What we call the *characters* of natural objects are merely the signs by which we judge of affinity, and in one

sense are artificial, inasmuch as a natural group can never be defined by fixed characters.*

(47.) For in proportion as neighbouring groups are approached, those of the group under examination are liable to numerous exceptions.

(48.) It therefore follows, that these definite characters are but a declaration of the prevailing tendencies (*nixus*) of groups.

(49.) Hence it follows, that natural affinities are well represented by circles, which impinge upon and blend into each other at certain points.

SYSTEMA NATURÆ.

GENERAL CONSIDERATIONS.

THE multitude of objects included in the animal, the vegetable, and the mineral kingdoms, are to be regarded not only in their individual aspect, but also in their relations to each other, as forming parts of *one vast plan*, as harmonious†

* There seems some confusion or contradiction here, the paragraph appearing to refer to species, whereas the heading refers it to groups, in which latter case only it is true, for the characters of a species cannot be said to be merely signs of affinity.—*Wern. Club.*

† With such exactness and harmony is the chain of nature composed, that the absence or destruction of any one link would inevitably plunge the whole into inextricable confusion. There are some groups of living creatures, indeed, whose existence, to our partial and finite views, may seem almost without an object, or if it has one, to be only the annoyance and plague of man. But, to a reflecting mind, it will soon be apparent that the annihilation of any such, though inconvenient and even noxious to man, "would make a blank in nature and prove destructive to other species," for whose food and support the first may have been destined. "These," to use the words of a most agreeable writer, "in their turn would be the cause of destroying other species, and the system of devastation would gradually proceed, till man himself would be extirpated, and leave this earth destitute of all animation."—*Wern. Club.*

in itself as that of a beautiful building made up of a vast number of subordinate parts; and, whilst the diversities of form and aspect seem almost infinite, they are evidently referable to certain general principles, which produce not only the manifest conformity but also the apparent departures from it. Having in the preceding paragraphs explained such of them as have yet been discovered, we will now proceed to trace their outlines. Before, however, commencing this survey, it will not be improper that it should be preceded by other descriptions of a more general character, and that the mind should be first awakened to some perception, indistinct though it be, of the primary laws which seem to embrace and pervade all creation. Organic and inorganic matter, vast as we know them to be, form but a part of the system of the universe. The chain of affinities is, in short, infinite; and although man can never hope to analyse more than a few links, yet sufficient light has been given him to discern their connexion with things that stretch into the realms of the immaterial world.

"Every thing which the mind of man can conceive is either cogitative or incogitative;"* or, in other words, is either intelligent or unintelligent. "Of intelligent beings there is but one universal, primary, and continuous Cause—God, in whose hand is the life and being of every thing. From the will of this great Creator have emanated other intelligent orders, created indeed, and therefore incontinuous, but whose entire nature being spiritual is incorruptible, and who have been destined to live by their Creator in that state for ever. Following, but far removed from, these purely spiritual beings is man, whose essence or soul is immortal, but whose substance or body is material and corruptible. These, for a season, are united; but the soul will continue to exist throughout eternity, and by obedience to the conditions which it has pleased God to reveal to us, it will hereafter be united, so to speak, with the purity and holiness of Him from whom it proceeded."†

* Locke. † Swainson.

Of unintelligent beings or things we can only conceive three sorts, namely, matter, time, and space.*

Matter is incontinuous, but time and space are without end. These likewise differ from intelligent beings, in that they are *capable* of mensuration. Time and space are eternal; for it is impossible to conceive them otherwise than as co-existent with the Deity. "All eternity is His duration, and all space is filled with His presence." Of time we know but of three primary divisions, which we distinguish as the past, the present, and the future. The first and last are incalculable, for they are eternal, while "the present" is but as a connecting filament to each. Space, in like manner, may be broken into portions; but of its first great divisions we know nothing more than can be dimly gathered from certain passages in revelation. We have said that matter is distinguished from space by its incontinuity; we may, therefore, also add, by its finiteness. But where this termination of matter is to be found we cannot say, when the almost inconceivable truth stands before us of the numbers and distances of the worlds that are actually visible. The demonstrated wonders of astronomy deprive us of the right to affirm, that any supposition concerning the greatness of the works of God is too vast to be admitted.

OF MATTER AND ITS DIVISIONS.

1. The true nature of matter in its most general sense has never yet been, and probably never will be, clearly understood. It is usual to consider matter as divisible into *ponderable* and *imponderable*.

2. Ponderosity is evidently the chief or typical distinction of matter, and is that quality by which it is most widely separated from both time and space.

3. No two particles of ponderable matter can occupy the same place at one time, and no one particle can be in different

* "Of unintelligent beings or things;" read *existences:* for it seems scarcely proper to term such an ideal something as time a "thing," and empty space is, in fact, a mere void.—*Wern. Club.*

places at the same time: by the first we demonstrate its solidity, by the latter its identity.

4. Ponderable matter, when its particles are collected together and united into a compact mass, which possesses a definite form, is termed a body, and of such bodies we know only of three sorts, viz. animals, vegetables, and minerals.

5. The two first of these are termed organic; that is, they possess an internal organisation for their growth and increase.*

6. Minerals, on the other hand, are inorganic; without life, and probably increase by external depositions alone.

7. These three divisions of matter constitute what are termed the three kingdoms of nature.

Having given the fundamental truths upon which the natural system rests, and our present work embracing the third and last-named of these divisions more particularly, we purpose entering more fully upon that one subject, treating it in accordance with the views already given, and carrying out the system in this relationship, leaving it to others to make further investigations with respect to the two former divisions.†

* The dictum of Linnæus, that "stones grow, vegetables grow and live, animals grow, live, and feel," is open to exception. The following appears to be the best definition of an animal yet given, though at present, from reasons before stated, it is scarcely possible to draw any distinct line between vegetable and animal life: "Animals are possessed of an internal receptacle for food, wherein they collect the nutriment destined for their support; in other words, they are provided with a stomach, while plants are only permeated by tubes, through which the nutritive juices flow equally to every part."—*Wern. Club.*

† Swainson's work, already referred to, will be found to contain all information relative to the higher divisions of organic nature. We are not aware whether any publication has treated the second division of that class in the same light.—*Wern. Club.*

APPLICATION OF THE SYSTEM TO MINERALS.

THE requirements of modern chemistry are so numerous that, if admitted to their fullest extent without inquiry, a total overthrow of existing views in this department of science takes place, and a new system, more complicated in its details, is substituted. Hence it becomes a matter of necessity to examine into the claims of each modern discovery, and, without questioning the validity of any of them, to enter into the comparison of the systems, as laid down by the authors of each.

But let it be understood that we do not propose a mere "system of arrangement" as the basis of our inquiry—purposing that its extent should only be limited by the attainment of such a general view of the subject as shall enable us to draw certain general conclusions of more definite utility than the mere question of classification—to demonstrate that what might be ascribed to chance is the result of a fixed mode of combination—and having proved this, to deduce certain arguments from the evidences of design which they present to our notice, calculated to support, even in this kingdom of nature, unattempted as it has hitherto been, the truth of those maxims which ascribe wisdom to the Creator in the least as well as the greatest of His works.

Doubtful and difficult as this may appear at first, a closer acquaintance with the subject will be the means of expanding this science of technicalities into a study of infinite importance and utility, based upon an equally comprehensive system of natural agencies and attributes as is to be found in the study of higher departments of natural

products, and philosophy. That this should have become such a science of technicalities is solely attributable to the want of generalizations being made; and therefore no apology can be required for performing what appears to us to be merely the office of a reviewer, without further claims on originality than are displayed in taking new views of any subject on the completion of such a duty; and as such it also becomes a matter of necessity to clothe these views in such simple language that the subject is rendered intelligible to all.

This work owes its existence to the following particulars:—

Firstly, That whereas the generally approved systems of mineralogy recognise three distinct classes, *earthy*, *metallic*, and *inflammable* minerals, the discoveries of modern science would *seem* to modify these to an almost unjustifiable extent, by the resolution of many earthy elements into oxides or other mineralized forms of metallic bases, and the dismissal of the class of inflammable minerals from the system of classification altogether, as being mineralizers only.

Secondly, However true it may be that many so-called earthy elements are only forms of metallic elements, yet the ultimate form of these is so extremely remote as to be beyond the art of detection by the mineralogist who is unprovided with costly apparatus, and hence greatly increasing the difficulty of determining the respective qualities of specimens, it becomes requisite to procure a means of detection which shall be available to all.

Thirdly, That the mean between the extremes presents, to our minds, a system equally correct, more consonant with established views, and one which presents the subject under many new aspects.

Such being the state of the case, we must leave it to our readers to determine, after a due perusal of these pages,

whether the object we have in view has or has not been carried out, and whether the conclusions at which we shall arrive (agreeing with the third of the reasons above stated) are, or are not, founded on facts.

THE SCOPE OF THE SCIENCE OF MINERALOGY.

As our subject treats of the simple components of the earth and their combinations, the rules under which they occur, and their modes of occurrence, it is, in fact, so far as its fundamental principles are concerned, purely *chemical* in its nature; assuming, however, a distinct form when the geognostic relations of minerals to each other are concerned, thereby identifying certain mineral products with certain formations, if not with fixed localities.

THE FUNDAMENTAL PRINCIPLES.

Elementary forms being the basis of all combinations, let us regard these first, classifying them as follows, viz.: —

I. *Gaseous.*	II. *Inflammable.*	III. *Fixed.*
Hydrogen,	Carbon,	The Metals,
Oxygen,	Sulphur,	&c.
&c.	Phosphorus,	
	&c.	

in all, fifty-five in number.

The *gaseous elements* are not to be distinctly identified in mineral substances, being only *agents* in certain transformations.

Inflammable elements are rare in nature (if they ever occur?), and, when found, are almost always *agents*, howsoever pure they may appear to be.

Hence, the third and only remaining division (*the fixed elements*) is that which is most important to be studied, inasmuch as it embraces a wider field than the others, either individually or combined, and as its contents are *complications*, the elementary principle in every case being a pure metal.

FIXED ELEMENTS.

A reference to the figure (Pl. I.) will shew the threefold nature of the fixed elements, as follows: —

The *earthy minerals* being the results of gaseous action upon a fixed base.

The *inflammable minerals* being (most probably) a volatile inflammable substance, assuming a fixed form on its combination with a base similar in its nature, though dissimilar in its properties.

The *metals* being the ultimate form under which most of the elements occur, and which is, therefore, the fixed form most prevalent in nature in a pure state.

We shall consider each class separately under a future head, contenting ourselves at present with defining the different *agents* in the two first classes, and the *mineralizers* in the third class: of these there are the following:—

No. 1.	No. 2.	No. 3.
Agents.	*Agents.*	*Mineralizers.*
Hydrogen,	Sulphur,	All the metals in
Nitrogen,	Phosphorus,	a greater or less
Oxygen,	Carbon,	degree. (*Vide*
Fluorine,		chapter on this
Chlorine,		head.)
Iodine,		
Bromine,		

$\underbrace{\hspace{20em}}$

Severally acting upon a fixed base.

The conclusions to be drawn from the foregoing facts are, briefly, these (*vide* Plate I.):*—

* In the diagram accompanying the text the following distinguishing colours are used to identify the parts of the figures in each instance with the elementary origin of their contents.

The prevalence of gaseous agency coloured red.
" inflammable agency .... yellow.
" mineralizing agents .... blue.

The combinations of colours always indicate the relationship

1. That *earthy minerals* are allied to both the fixed elements and gaseous elements, inasmuch as they are the products of the chemical action of the latter upon the fixed base (always a metal).
2. That *inflammable minerals* are allied to both fixed elements and inflammable elements, inasmuch as they are the products of an inflammable agent acting virulently on an inflammable element.
3. That *metals* are allied to both of the first-named elements, as they are the products of the combination of either or both agents with a fixed metallic element, preserving their distinctive *metallic* character under the change.
4. That metals being, therefore, the aberrant group in the triune system herein adopted, are to be further considered as follows, viz.:—
    1. Metals *mineralized by an ally of a gaseous elementary agent;* such, for instance, as the oxides, hydrates, &c.
    2. Those *mineralized by an ally of an inflammable elementary agent;* as sulphurets, &c.
    3. Those *mineralized by another metal;* as titaniates, molybdates, chromates, &c.

Whilst those metals which are mineralized by another of their own family are subdivisible into,—

1. Those which are products of chemical action effected

which the various products bear to each other in their mode of constitution.

Thus $\frac{\text{red}}{\text{gaseous}}$ combined with $\frac{\text{blue}}{\text{fixed}}$ equals $\frac{\text{earthy minerals}}{\text{purple}}$

" $\frac{\text{yellow}}{\text{inflammable}}$ " $\frac{\text{blue}}{\text{fixed}}$ " $\frac{\text{inflammable minerals}}{\text{green}}$

Blue conforming with blue, leaves the colour the same, and represents *metallic.*

by an acid composed of gaseous and metallic bodies;* viz. *silicates, aluminates, &c.*

2. Those which are products of chemical action effected by an acid composed of gaseous and inflammable elements; viz. *carbonates, &c.*
3. Those which are products of chemical action effected by an acid composed of gaseous and metallic elements (in more immediate connexion than those classed under the first head); such as *arseniates, chromates.*

By this investigation we have established a well-defined system of analogies based upon the acting or mineralizing agent; thus an analogy exists between

I. Gaseous elements, earthy minerals, oxides, &c., silicates, &c.

II. Inflammable elements, fixed inflammable elements, sulphurets, &c., sulphates, &c.

III. Fixed elements, metallic elements, mineralizing metals, arseniates, &c.

And the further we carry out this system the more clearly does it appear to explain the mutual relationship between elements and agents, and their combinations, whilst the point at which we arrive, and from which we are to extend our inquiries, is always the aberrant group of mineral forms, more dubious in their respective characters than the rest, and, consequently, capable of almost infinite subdivision.

It must also be obvious that the student, by these means, is enabled to assign, to any individual specimen, the proper position in the system of analogies, and has, therefore, only the labour of testing the fixed element, and the agent or mineralizer engaged in the transformation of that fixed base into the form which it presents to his notice.

* It must be understood when we here speak of acids composed of equivalents of gases and metals, that we allude to the *ultimate* forms of each of the equivalents.—*Wern. Club.*

EARTHY MINERALS.

Passing over the two first groups of *elements*, gaseous in their nature (or supposed to be so*), our subject opens with the third in its various bearings with respect to earthy, inflammable, and metallic bodies. And with respect to earthy minerals, we have already seen that they are to be resolved into families according to the different gaseous agents by which their changes are governed.

Not many years since, the earthy elements were passed over without investigation, the general opinion being that silica, alumina, &c. were native elementary substances, until the researches of modern science proved them to be only forms of a metallic element (or fixed base), immensely increased in volume by the action of the components of the atmosphere, so intimate in their union with each other, that the metallic form was altogether lost and rediscoverable only with great difficulty.

This novel fact created, of course, a great revolution in mineralogical science, and established a new and intimate relation between the earthy minerals and metals.

The discovery that they were only forms of metallic bases was apparently an entire overthrow of former views—more so than was warranted when we consider the relationship which exists between the agent and the base—one which, if in its *effects* it assimilates the products to the earthy minerals (so called), detracted in nowise from the original

* No inflammable elements exist in a gaseous form. Sulphur, carbon, and phosphorus, are all solid bodies as we know them; but they occur in nature much less pure than the elements themselves. Native sulphur is less pure than the element sulphur, &c. &c. This is the only imperfect member of the series of analogies upon which this system is founded; but it does not in any degree invalidate its correctness, as it finds the inflammable minerals in their natural place amongst the fixed elements, and only *presumes* that, like the ultimate form of earthy minerals, their ultimate form is likewise gaseous, and this by a very fair inference.—*Wern. Club.*

element either with respect to its metallic character or properties; for we can easily imagine that many earthy forms of metals, arranged under the head of "Metals," would be as readily assigned to one place as to another by a tyro, so similar is their appearance and general character. We allude, of course, to earthy oxides of iron, Fig. 3 (Hæmatite), various compact forms of carbonate of copper, Fig. 4, carbonate of zinc (Calamine), which are only detected by an experienced eye. The difficulty is even increased when we suppose the same tyro to be called upon to pronounce upon the respective characters of crystallised specimens of earthy minerals and the crystallised forms of arseniate (Fig. 5), phosphate, and carbonate of lead, &c. &c.

The earthy minerals were classified under the following heads, as compounds of earths, viz.:—

Silica	Magnesia	Barytes
Alumina	Lime	Glucina
Yttria	Strontia	Zirconia

Siliceous earthy minerals, or compounds of silicium.—Silex—the main constituent of all flinty minerals—is an exceedingly remote form of the metallic base "silicium," which in colour is of the metallic bluish white, and this, its only known simple compound, is colourless. Hence all specimens of pure flint and quarz are either transparent or opaque white, crystallizing in proportion as there is a smaller or larger quantity of water in their composition. It is interesting, therefore, to trace the agency of foreign ingredients in the effects which they produce. As, for instance, in

*Common Quarz** (Fig. 1).

Silica..	$99\frac{3}{8}$
Loss	$\frac{5}{8}$
	100

Amethyst.†

Silica	97·50
Alumina	0·25
Oxide of Iron....	0·60
Tr. of Manganese	
Loss	1·75
	100·10

Ferruginous Quarz (Fig. 2).
Silica, with more or less Iron.

Rose Quarz.
Silica + Manganese.

* Bucholz. † Rose-Karsten's Tabellen.

The translucent angles of Fig. 2 shew the real nature of the original unalloyed mineral.

It is not our design to enter into the description of all the forms of each mineral, nor would this part of our work then prove more interesting than any treatise hitherto published. The weight of our argument is readily apparent from an inspection of the minerals which we have represented for that purpose, and to the explanation of which we shall confine ourselves for that reason.

Silica* occurs in combination with all the other earths, in many cases several entering into the same mineral. Thus we have

Silica, alumina, and lime	=	Heulandite.
Silica and iron	=	Garnet, &c.
Silica and barytes	=	Harmatome.
Silica, magnesia, and lime	=	Augite, &c.
Silica and magnesia	=	Asbestos, &c.

and it is rare indeed to find any compound either transparent or colourless. A few compound minerals indeed are of an opaque white (pargasite, harmatome), generally more or less tinged, denoting the presence of some colouring ingredient, and these only seem to substantiate the groundwork on which we found our views.

Of the Compounds of Zirconia and Glucina we have but a few, generally highly coloured from the presence of a metal; whilst, as regards *Magnesia*, which is found nearly white when unalloyed (hydrate of magnesia; meerschaum), we have various minerals more or less coloured, such as serpentine, steatite, and chlorite; and these are all complex forms.

Yttria.—The only mineral in which this earth occurs in any quantity is the gadolinite (45 per cent), in which it is

* The colouring matter is *always* a trace of some metal, perhaps almost imperceptible on analysis.—*Wern. Club.*

† We consider it better to preserve the ordinary terms in our descriptions, rather than adopt the more correct chemical appellations, having explained their relations.—*Wern. Club.*

combined with silica and a metal, the latter imparting to it a dark colour, either intense black or red.

Alumina is more abundantly distributed than any of the four last earths,—its most pure form (aluminite) almost white, whilst all its compounds are more or less coloured, not so much from direct admixture of a metal as in many instances owing to the presence of potash, which, from its peculiar metallic origin, has a similar effect. So, for example, all the varieties of mica and felspar are more or less coloured, whilst the volcanic minerals embraced under this head are always very dark in colour, owing to the increased chemical action on that substance, occasioned by their geognostic situation.

Lime, perhaps the most prevalent of any of the so-called elementary constituents of solid matter, embraces a large number of mineral forms, generally speaking less coloured than any other class of minerals. It is curious to observe how those forms acted upon by acids only retain the opaque white colour, whilst the admixture of even a trace of metal imparts a tinge to the specimen. There is only one exception to this rule, in the case of fluor, which ranges through almost all the gradations of colour, whilst the analysis of each variety does not afford sufficient information to identify the cause.

The same remarks apply to *Barytes* and *Strontian* (the two remaining earths), the colourless forms of which are rare, whilst those acted upon by metals are abundant.

All these earths, as in the case of silica, are exceedingly remote forms of metals, acted upon precisely in the same manner and in nearly the same equivalents.

We have said thus much on the subject of colour to identify metals as the cause of its occurrence in minerals, and we think the evidence highly satisfactory. The only exception is fluor, which, as if to put a limit to theory, opposes itself to our views, not without affording us a salutary lesson by way of checking our speculations; not to overthrow other undeniable facts, but to demonstrate that there are hidden causes, as well as those which are dis-

covered, intimating that we can only know *in part*, and that, though a general rule is observable, it is in the power of Him who created inanimate as well as animate objects to shew His power therein as well as in the higher departments of nature. These evidences require to be searched out.

The intermediate place which earthy minerals occupy between the gaseous elements and *terrates* of metallic minerals is, we believe, quite clear from this review of their constituents, bringing them all within the circle of fixed elements, and tracing them all to be only forms of metals.

INFLAMMABLE MINERALS.

As regards *inflammable minerals*, which rank with the preceding in their earthy appearance, we can but quote the various fixed bases, without attempting to resolve them into a still more elementary state than their solid form, although the analysis of the system in other respects is a good ground-work for synthetical arrangement in this.

The fixed bases of inflammable minerals are carbon, sulphur, and phosphorus, which have hitherto defied all attempts at further reduction,—the two former alone occur as mineral forms, whilst the latter is an active agent in the transformation of metals, and is also prevalent as an ingredient in many earthy minerals. Combining as they do with metals, the products stand precisely in the same relationship to the latter as the earthy minerals themselves, being the fixed form of a gaseous element acting on a fixed base, although we are unable to trace any connexion equivalent to the relationship between the base of the earthy minerals and metals. We should observe in this place, that this relationship is by no means essential, as the system does not aim at the reduction of all mineral forms to a metallic base, we only trace less and less of the agency of extraneous substances as we arrive at the aberrant point in each (see Plate I.) group, and hence are enabled to form some estimate of the purity of the metallic base itself, so that by degrees we trace definite affinities in every group. The plate already

referred to exemplifies this harmonizing system of combinations, and exhibits the types in each group more clearly than any other description.

METALLIC MINERALS.

If number of elementary forms and modes of occurrence are any proof of importance, these can claim it beyond doubt. They may be declared the types of those vegetable forms which are not only of the nature but also encircle the stems and branches of other kindred plants, leaving it doubtful which of the two gives the character; so with metals, they enter so generally into the composition of almost all minerals, that one is at a loss sometimes to identify the characteristics by sight.

It is very evident, even to the tyro, which of the metallic minerals are products of the gaseous, and which are those of the inflammable agency upon the fixed base. The difficulty we have already alluded to, as existing when it becomes necessary to identify earthy and metallic minerals, may again be urged in this place, both by way of elucidation and example. The oxides, hydrates, &c. are earthy in their appearance, so are the silicates; never crystallizing, they contrast most strikingly with the sulphurets, carbonates, arseniates, chromates, &c. which almost always assume that form. The products of gaseous agency are often only *investing*, instead of homogeneous minerals, whilst the inflammable agents pervade the whole mass; as if it were a means whereby deleterious exhalations became absorbed, without entering into the composition of the atmosphere, and rendering it less pure. Besides the further identity traceable on the side of gaseous transformations in their preserving the investing form, this is exemplified in a striking manner in the instance of the gossans which accompany metallic lodes. This portion of the review does not admit of the same classification as earthy minerals; for, in many instances, the metals occur *pure*, in all cases their combinations with one or other class of mineralizers is apparent,

and in very few instances comparatively do we find the same active combinations as in earthy minerals.

In fact we find ourselves, at this stage of the inquiry, involved in such a labyrinth, owing to the *passive mineralizations affected by pure ores one upon another*, that there is no question as to the rank which these occupy in the system. It identifies such minerals most completely with the aberrant group.

CONCLUSIONS.

From the above considerations it appears that there is a simple affinity between the gaseous elements, earthy minerals, &c. in one case, and inflammable elements, inflammable minerals, &c. in the other (vide System of Affinities, § 7); and we have traced it both in respect of colour and constituents. The external affinities exist between the groups next before and after each circle (vide Plate) in both sides of the progression towards the point identifying the gradual approach to the aberrant group itself, the circle of each group which is situated nearest the convergence of the lines being the aberrant group of each. We also trace in the aberrant groups all those principles which prove their contents by the rules laid down in § 14 of the heading above referred to. The external affinities to the *typical* (gaseous elements) and *sub-typical* (inflammable elements) being remarkably developed.

The gaseous elements constitute the typical group in the first instance, as the agents contained in it are the most perfect, and capable of performing, to the greatest extent, the functions which peculiarly characterise the contents of the different circles of affinity. We see how intimately they are associated with them, and, in proof of the truth of § 24 of the same heading, we see with what accuracy we are enabled to locate the types and fill up the chasms in what would otherwise be imperfect groups.

The other considerations to be deduced from this review and arrangement of the constituents of the mineral kingdom are important. They demonstrate that the agency of those of the gaseous elements which are essential to the life of man, and to the well-being of animate nature in general, has an equal share in the mineral kingdom. These elements are, in the aggregate, a type of the all-pervading "spirit of God," which, from the day when we are first told that it "moved on the face of the waters" until now, has quickened, and still quickens all nature, and extends itself more especially to man. It is one of those hidden indices by which we may perceive *design, the most elaborate*, throughout the fabric and frame of things created, and which alone would convince us that Science can do nothing more noble than to aim at being the handmaid of Religion. When we see such definite modes of combination in minerals, and are wont to attribute them to natural laws only, the evidence which we have adduced of affinity to each other, and the types we have endeavoured to establish between groups, ought to lead us to regard such as parts only of one vast design, too subtle for our investigation and much too infinite.

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PLATE I.

SYSTEM OF MINERALS, &c.

Shewing thar

AFFINITIES.

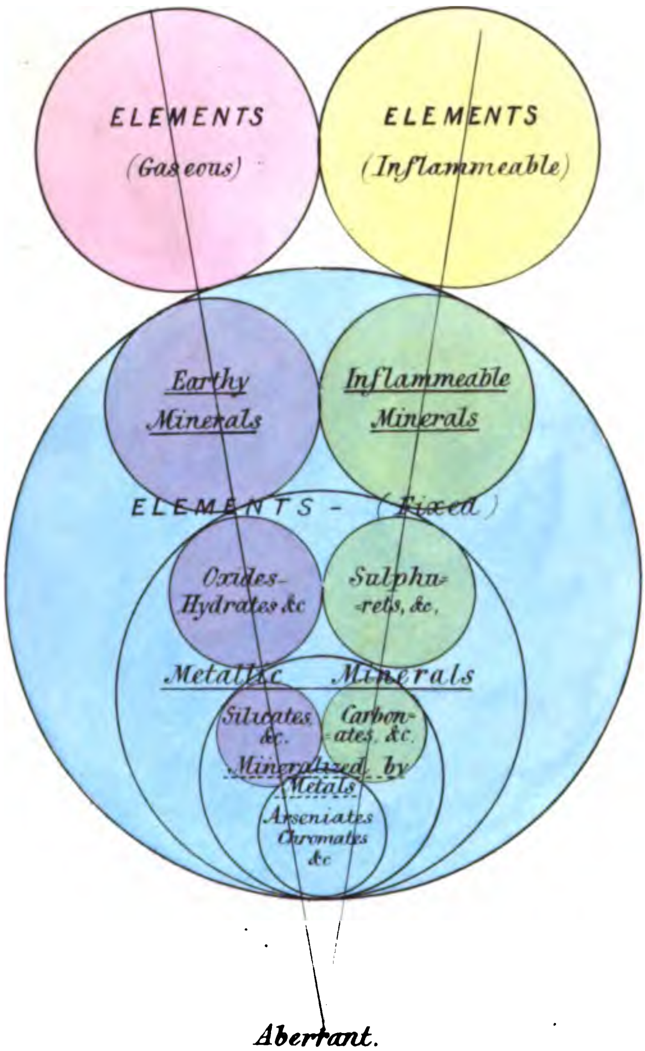

PLATE 2.

Fig: 1.

Fig: 2.

PLATE 3.

Fig. 3.

Fig: 4.

Fig: 5.

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